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Contents.

	PAGE
Notes and Comments	269
The Protection of Workmen's Eyes	271
The Growth of Cast Irons after Repeated Heatings	272
A Small Detachable Open-Hearth Furnace	279
High-Pressure Gas for Metals	281
The Constitution of Cast Iron	282
Specifications of Motor-Car Steel	286
Iron and Steel Institute	287
Checkweighing in the Iron and Steel Industries	287
Making a 12-ft. Rope Pulley	288
Important Points in Foundry Practice	290
Chromium in Non-Ferrous Alloys	291
Mechanical Core Making	292
Moulding a Conical Flanged Pipe	294
The Hering "Pinch Effect" Furnace	295
Problems of Foundry Practice	298
Alloys of Aluminium and Zinc	301
Foundry Plant and Equipment	304
Inventions	307
Queries	308
"F.T.J." Bookshelf	308
Trade Talk	309
Deaths	310
Personal	312
Prices of Metal	314
New Companies	314

Forthcoming Events.

MAY 4.

British Foundrymen's Association (Lancashire Branch).—Election of Officers and Discussion by Members.

MAY 9 & 10.

Iron and Steel Institute.—Annual Meeting in London.

MAY 18.

British Foundrymen's Association (Newcastle Branch).—"The Cupola and its Management," by H. Pemberton.

British Foundrymen's Association (Halifax Branch).—Election of Officers and general business meeting.

MAY 25.

British Foundrymen's Association (Birmingham Branch).—"The Production of Iron and its Alloys in the Electric Furnace," by J. H. Stansbie, B.Sc., F.I.C.

NOTES AND COMMENTS.

Iron or Steel for Ingot Moulds.

In the course of his lecture on "The Growth of Cast-Iron," delivered recently before the British Foundrymen's Association, Professor Carpenter referred to the difficulty of growth which is so frequently experienced in ingot moulds for large steel ingots. The practice in this country is to cast the moulds in question of an open grey hematite pig-iron, with phosphorus and sulphur low and silicon kept within defined limits; but the life of such moulds is not great, being, according to circumstances, from 150 to 180 heats. It has been suggested that mild steel is the better material for such moulds, but the suggestion has not been received very favourably. In justice to the claims of steel, however, it must be stated that in Germany steel is largely used for such purposes, and gives satisfaction. In the various discussions on Prof. Carpenter's lecture the contention was put forward that the molten steel would bite into the face of the mould, rapidly destroying it and rendering the mould useless; and experience in that direction was cited by several speakers. According to information published in "Stahl und Eisen" a few months ago, however, not only the trouble mentioned, but also other difficulties in connection with the use of steel for ingot moulds have been overcome in German practice, and several works in Germany habitually use steel, and not cast-iron. The moulds, further, should not be water-cooled but merely air-cooled. The average life is then stated to be 250 heats, while single cases of 300 heats are not infrequent. Another advantage is that the melting of the base-plates of cast-iron moulds, which is so unpleasant a feature of their use, is entirely avoided, and the ingots are turned out sharp and clean. The solution of the difficulty of the molten metal fusing the face of the mould is in the dressing of the mould prior to pouring, a procedure which is common enough in the casting of other metals in permanent metallic moulds.

As to the question of a suitable composition of steel for ingot moulds, it was elicited during discussions on the subject that excellent results had been obtained with steel containing from 0.30 to 0.35 per cent. of carbon, two moulds of this metal having stood 340 and 342 heats respectively. In another case it was reported that successful results had been obtained with steel containing 0.25 per cent. of carbon, while in yet another hard-steel mould containing 0.75 per cent. of carbon was stated to have lasted 270 heats. From these results it would appear that there is a considerable variety of choice as regards the most advantageous composition, though exhaustive data is not yet available. With reference to first cost, Prof. Carpenter stated that there are various places in Germany where open-hearth or Bessemer steel is cheaper than grey hematite pig-iron, which costs about 70 shillings a ton. Further, a higher price can be obtained for scrap steel than used cast-iron moulds. Under these circumstances, therefore, it is not surprising that in Germany the tendency is to substitute steel for cast-iron in making ingot moulds. The conditions being somewhat different in this country, it is probable that hematite iron will long hold the field

for the work in question, though it would be idle to suggest that, even in view of Prof. Carpenter's non-growing iron, steel will be precluded from seriously encroaching on the field now held by iron.

The Reliability of Aluminium Castings.

A not uncommon opinion existing among foundrymen is that while aluminium alloys present many advantages on the score of lightness and strength, they are not sufficiently reliable to be ultimately approved by engineers requiring material to stand stress over protracted periods. A number of factors have conduced to this opinion, not the least important being the handling of such alloys by men with little or no knowledge of their peculiarities; while also, the range of compositions that will give a comparatively good-looking casting is very much wider than the range of alloys possessing really high strength. This means that the aluminium alloys are essentially materials to be handled by the man who understands them, and is aware of their peculiarities, rather than by founders accustomed to the brasses and bronzes only. But not only does the founder require to thoroughly know his metal; the designer, too, must understand the peculiarities of aluminium, particularly as to high contraction and red-shortness. These facts are often overlooked in the design, with the result that unaccommodated shrinkage, accompanied by weakness just after setting, results in strains and weakness in the finished castings, even if crackings do not occur during cooling. It may here be said that while much stress is laid by some writers upon a distinction between shrinkage and contraction (the former being said to refer to the reduction in bulk while molten, and the latter to the reduction after solidification), such a distinction is artificial and misleading; the real distinction between liquid contraction and solid contraction, to use the more correct phrases, is that during liquid contraction feeding may be employed to aid solidity and soundness, while in the latter stage it cannot. The great solid contraction of aluminium must, therefore, be met by care in designing, particularly in view of the low strength during the latter part of the cooling process. Not only must the thickness be arranged to vary as little as possible, but the mould must be prepared so that the total shrinkage is not unduly impeded.

The danger of filleting is frequently exemplified in aluminium; for often where fillets have been introduced to give soundness and avoid sharp alteration in design, they serve rather to give extra thickness and to provide space for shrinkage holes. Where a fillet joins up a thicker portion which is properly fed, it may be quite serviceable, but where such is not the case it may easily be too big, with the defects mentioned. It should be borne in mind that the strength of a casting does not depend so much on the actual size of the different parts in relation to the strain they will have to bear, as upon the relation in size and shape which those parts bear to one another. One part may, by itself, give a definite test result, as, for example, a 12 in. by 1 in. by 1 in. test bar cast separately; but when it forms a part of a complicated casting, and has various smaller parts attached, the effect of the latter, by reason of "drawing" during solidification, may reduce the strength of the former to less than that of the smaller parts it is feeding. Hence the strength of each part of a casting is largely dependent on the nature and effects of the parts in proximity to itself. If this were borne in mind to a greater extent when designing aluminium casting, much of the "unreliability" of the metal would be avoided.

Foundry Precautions.

The moulder, also, is in a position to introduce several factors that militate against the strength of the castings. To ram as for iron castings is to give an inflexible mould that at least induces internal strains during contraction, while the cores, if unduly hard, may give a similar result; too often, in fact, this feature of hardness in moulds and cores results in a cracked casting at once. The great shrinkage of the metal, further, demands that particular care be exercised in the placing of runners and feeding heads, so that heavy parts are kept supplied with metal as long as possible.

Weakness resulting from bad crystallisation may be caused by both bad design and incorrect pouring temperature. Excessive heat of pouring is a common fault with founders who wish to obtain clean, sharp castings; though a high temperature may be necessary by reason of small, thin parts to be filled, which would not be filled with cooler metal. Here the designer can often assist by slight alterations. Since the pouring temperature must necessarily vary according to the composition of the alloy and the nature of the casting, it is impossible to do more than draw attention to the facts above stated.

In enumerating the causes of defects in aluminium work, mention must be made of bad melting. Overheating of the metal should always be avoided, a low-red heat being suitable for most work; and every care should be taken to prevent undue oxidation. Practice varies considerably as regards protective coverings, some founders using none at all, but simply throwing salt into the metal before skimming and pouring. Oxidation, to some extent, is almost inevitable, but it can be reduced considerably by the exercise of commonsense and care. Since the oxides of aluminium are difficult to remove, however, and also form very rapidly, they are commonly the cause of defects in work produced by inexperienced men.

The whole subject may be summed up in this; the aluminium alloys are not inherently unreliable if properly handled; but they require treatment which takes into consideration their special peculiarities compared with other metals. This means that the aluminium founder, to be successful, must give as much study to the metal as he would to any other special and unknown alloy; haphazard methods will not serve. There is, of course, the question of the composition of the alloys for different purposes, and it must be admitted that it has a distinct bearing on the question of reliability; but that is another and a very large subject.

Oil Firing for Open-Hearth Furnaces.

In connection with the description of the Carr oil-fired open-hearth furnace published on page 279, the following particulars of an oil-fired open-hearth furnace for steel castings and special steels at the Tsaritsyne Works, Russia, abstracted from a description by Mr. E. Richarme in "Revue de Metallurgie," will be of interest.

The principal dimensions of this oil-fired furnace are:—Length of hearth, 14 ft.; width at the level of the burners, 6¼ ft.; mean height, 3½ ft.; air flue, 44 by 6 in.; slope, 30 degrees; slope of burners, 14 degrees. The bed is formed of two layers of magnesite bricks (the upper one laid on edge) covered with a layer of granular magnesite mixed with 25 per cent. of slag. The end wall is of magnesite bricks, and the front wall of magnesite brick below, and silica brick above. The injectors through which the petroleum residuum used as fuel is forced into the furnace, are arranged one on each side, and are sloped at a low angle to prevent the direct im-

pact of the jets on the surface of the metal bath. The arch is made of large silica blocks.

The furnace was started working in April, 1907, and in November, after running 1,129 charges, was stopped for cleaning out the slag boxes. The end walls and door arches were repaired at a cost of 756 roubles (about £80), but the arch of the furnace and the chequer-work of the air chambers were still in good condition; in fact, both these portions of the plant lasted out a run of 1,694 charges before part of the arch collapsed. Examination then showed extensive corrosion of the arch, and both ends were corroded at the springings of the arch, the flues being also more or less eaten away. In the air chambers the upper layers of silica bricks were discovered to be fused, and about half the cells in the next layer were choked up, the rest of the chamber being in fairly good condition. The total cost of repairing these defective parts of the furnace and air chambers amounted to 2,113 roubles (£220). Up to the time of these repairs the furnace had been run for 591 shifts, or 1,694 charges (each of an average of 264 poods, or 4¼ tons), the net production per 24 hours being 1,432 poods (14 tons). The consumption of charging material included:—Hematite pig, 172,651 poods (2,785 tons); scrap, 270,126 poods (4,357 tons); 80 per cent. ferro-manganese, 1,783 poods (29 tons); 50 per cent. ferro-silicon, 1,115 poods (18 tons); or 445,675 poods (7,189 tons) in all. To this must be added:—Ore, 10,172 poods (164 tons); flux, 26,177 poods (422 tons); magnesite and dolomite, 4,921 poods (80 tons); and fuel, 57,998 poods (935 tons). The total production amounted to:—Ingots, 387,053 poods (6,245 tons); molten steel for castings, 36,212 poods (584 tons); and waste in runners, gates, etc., 5,079 poods (82 tons), a grand total of 428,344 poods (6911 tons).

Direct-Contact Heating.

Since that time the furnace, which has a capacity of about 4 tons, has been run continuously, with a stoppage for repairs once a year after an average run of 1,700 charges, and a mean cost for repairs of 0.7 copeck per pood (11d. per ton) of output. The consumption of fuel is 130 per cent., and since the heating value of this fuel is 11,200 cal., as compared with 7,300 cal. in the case of coal with 11 per cent. of ash, the foregoing consumption corresponds to one of 200 per cent. of coal. The jet of oil fuel is described as being directed toward the bath of metal at an angle of 14 degrees to the horizontal; a simultaneous examination of flame and furnace arch through smoked glasses shows that the arch is dark in comparison with the flame, and that there is a dark zone between the two; a circumstance which explains the long working life of the arch and also the large number of charges which can be worked in 24 hours. This arrangement of the flame so as to heat by contact with the charge is contrary to the theoretical recommendations of certain metallurgists, namely, that the heat should be reverberated from the arch of the furnace. As a matter of fact, Mr. Richarme states that the flame must be kept as far as possible away from the arch and as close as possible to the materials to be heated, in order that the arch may be protected from corrosion and the heating be effected with rapidity and economy.

The seven 20-ton furnaces worked on the same system at Tsaritsyne also act satisfactorily. The charges have the following composition per 1,000 parts of steel produced:—Hematite pig 670; scrap iron 360; steel scrap 20; ferro-manganese (80 per cent.) 4; Krivoi-Rog ore 60; rolling-mill cinders 40. The consumption of petroleum for heating and smelting is 150 parts, corresponding to 230 per cent. of coal containing 11 per cent. of ash. All the materials of the charge are put in cold. These 20-ton furnaces run for 1,094 charges before any extensive repairs are needed. The diurnal output is over 60 tons each; that is to say, three charges per 24 hours, on the average of the year's run, with an occasional output of 80 tons, or four charges, per 24 hours.

The Protection of Workmen's Eyes.

In a Paper read recently before the Pittsburg Foundrymen's Association, Mr. W. H. Cameron referred to the work done by the American Steel Foundries for the prevention of accidents at its several plants. He remarked that probably 75 per cent. of the accidents in steel foundries affected the eyes of workmen; and it became apparent to the above-mentioned concern, therefore, that it was necessary to provide all grinders, chippers, floggers, sand blasters, machinists, ladlemen, and others with eye protectors which would be suitable and comfortable and not impede the work or injure the eyes. An investigation of the use of spectacles and goggles in other industries showed that not one had been entirely successful in educating the workmen in the use of any style of spectacles. It was found, however, that the old fashioned type of grandfather's glasses has successfully protected the eyes of men working at emery wheels, and with these glasses as a foundation to build on, were designed the spectacles now in use, and which are worn by about 98 per cent. of the employés mentioned. The present design of spectacle is equipped with mesh screens at the sides and heavy lenses, the total weight being about 1 oz. per pair. A case is provided with each pair of spectacles, as well as a specially prepared cloth and paraffin pencil, used by automobilists to keep their glasses free from moisture and dirt.

The next problem was to have the glasses worn by such workmen as chippers and floggers, and it was found that these men would not voluntarily use the spectacles. An effort was then made by one of the plants to have the spectacles worn under the supervision of a watchman, who had time to circulate constantly among these workmen, and stimulate them in the use of the spectacles. On the employment of safety inspectors, however, this duty was relegated to them. As an additional stimulus to wear the spectacles, every cleaning-room workman was asked to sign a contract with the company, under the terms of which he agreed to wear the spectacles constantly, and in the event of injury to his eyes happening while at work without spectacles the company was absolutely free from responsibility for the accident. When spectacles were broken by flying chips, photographs were made of them and posted on the bulletin boards about the plants to illustrate the hazardous nature of the work. It is believed that supervision and education along the lines described will have to be adopted in all foundries employing a large number of chippers and floggers, for the reason that these men will not protect themselves voluntarily, and the foremen and their assistants are usually too busy to give special attention to the use of the spectacles.

The writer stated that he had a collection of 78 pairs of spectacles, the lenses of which had been damaged by flying chips over a period of less than three months. Fifteen pairs of these spectacles were received from one plant in one month. It is significant that only one eye was lost in all of the plants of the American Steel Foundries over the period of 17 months by workmen using these spectacles; in this one instance the piece of steel penetrated the lens with great velocity and entered the eye of the workman, and if the spectacles had not been worn a much more serious accident would have resulted.

The Growth of Cast Irons after Repeated Heatings.

Causes and Suggested Remedies.

By Prof. H. C. H. Carpenter, M.A., Ph.D.

Before the London and Sheffield Branches of the British Foundrymen's Association recently, Professor H. C. H. Carpenter, of Victoria University, Manchester, lectured on "The Growth of Cast Irons after Repeated Heatings, and under the Influence of Superheated Steam: Its Causes and Suggested Remedies." The results of Professor Carpenter's researches on this subject, as presented before the Iron and Steel Institute, have been published in substance in our issues of November, 1909, and June, 1911; but a brief survey of the matter will not be out of place here. We accordingly present the following abstracts from the lecture:—

So far as the author knows, the only person who had previously studied the cause or causes of the growth of cast iron is Mr. A. E. Outerbridge, jun., of Philadelphia. His chief contribution to the subject is entitled "The Mobility of Molecules of Cast Iron." In studying Mr. Outerbridge's papers it struck the author as a remarkable fact that he had made no attempt to connect the growths of the various cast irons with their chemical compositions. His papers do not contain a single chemical analysis of the alloys he was studying. There is nothing beyond the broad distinction between the behaviour of grey and white cast irons to which he alluded. We know, however, that cast iron is one of the most complex of the industrial alloys. In addition to iron, it contains carbon and silicon in notable amounts. Manganese, phosphorus, and sulphur, although variable, are always present in some degree; and there are the dissolved gases, of which hydrogen constitutes the greater part. Mr. Outerbridge denies that one of his bars, which grew 46 per cent., underwent any chemical change beyond a partial conversion of combined to free carbon. And the question arose: "Is this really so?" His experiments have certainly not proved it; and if it is not so, which constituent or combination of constituents is it which is influential in causing growth, and do any of the constituents present act in a retarding direction?

The author's investigation divided itself into the two parts indicated in the title of this lecture. Three preliminary matters had to be settled before the main experiments were entered on. In the first place, it was necessary to determine the conditions under which what may be called the "maximum rate of growth" of cast iron takes place. We found that at any given temperature there was as much growth after 3 hours as after 17 hours. Further, that under these conditions growth began to be discernible between 600 and 650 deg. Cent. At 675 deg. it was much more rapid, and at 700 deg. and at 730 deg. there were substantial increases. The maximum figure, however, was reached at 730 deg. Cent., no further increase even at 860 deg. Cent. being indicated. Above 900 deg. Cent. bars begin to scale, and accurate measurements are impossible. Our experiments, therefore, were limited to temperatures between 850 deg. and 900 deg. Cent., as these are doubtless reached and even exceeded in some of the practical uses of annealing ovens, and in order to be quite sure that the maximum growth for a given heat was obtained, the heating period chosen was 4 hours.

After some preliminary tests it was found best to employ cylindrical bars, to machine them accurately to a given length and diameter, and to measure their expansion by micrometer callipers. Bars 6 ins. by about 0.9 of an inch were employed, and both the length and diameter measurements were made to 0.0001 of an inch. The bars were heated in a grey cast-iron retort, which itself furnished an illustration of the distortion of this material after repeated heatings, this particular retort having been heated upwards of 50 times to 900 deg. Cent.

Influence of Carbon.

Our first series of experiments was designed to test the influence of carbon on growth. For that purpose, nine alloys were cast to our specification which contained only iron and carbon, so far as industrial conditions permit. The percentage of carbon descended broadly in half per cents. from 4 to the lowest figure that could be reached (0.15). The remaining constituents, silicon, manganese, sulphur, and phosphorus, were present in small and nearly constant amounts. The net result of these experiments was to show that so long as the alloys remained white irons, and eight out of the nine did so, not only did no growth take place, but there was a slight shrinkage which seldom exceeded 0.5 per cent. I ought to mention that in the later heats scale formed on the low-carbon members of the series, which rendered accurate measurement impossible, and which appeared to indicate a very slight growth of the bars. There is, however, no doubt that it was an apparent, but not a real, growth. So long as no free carbon was present the alloy did not grow. The moment it appeared growth was evident, and as the free carbon increased so did the growth. Free carbon was in this way proved to be in some way an indispensable factor in the growth of cast iron. The fact is of fundamental importance. Our

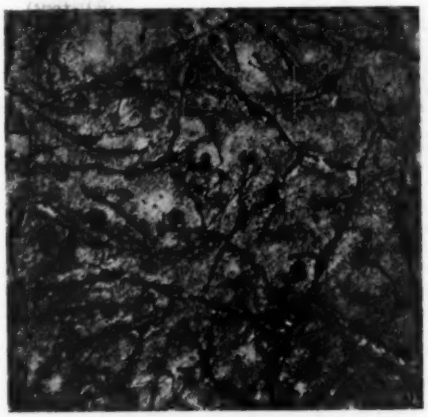


FIG. 1.—STRUCTURE OF ORIGINAL CASTING P. BLACK LINES REPRESENT GRAPHITE PLATES. MAGNIFIED 150 DIAMETERS.

calculations have shown that taking such data as are available as to the specific gravity of temper carbon, this precipitation of free carbon is sufficient to account for the volumetric changes we found in white irons that become grey after repeated heatings. This factor, therefore, cannot be disregarded, as Mr. Outerbridge has asserted.

Influence of Silicon.

Some time before the previous experiments were concluded it had become evident that the influence of silicon must be investigated. Of the alloys hitherto tested, one of which contained as much as 0.79 per cent. of this element, all those containing 0.65 per cent. grew from the outset, the largest growth being obtained with the highest silicon. Accordingly, the next series of alloys was designed so as to contain a constant quantity of carbon, about 4 per cent., and ascending percentages of silicon from 1 to 6 by steps of 1. Manganese, sulphur, and phosphorus were kept as low as possible. The reason for this choice was as follows:—It was argued that the earlier members of the series would contain some "combined" carbon, and that the latter would contain all their carbon in the "graphitic" form; that by repeated heating the former would tend to deposit their combined as "temper" carbon, and that if the growth of cast iron was due to an

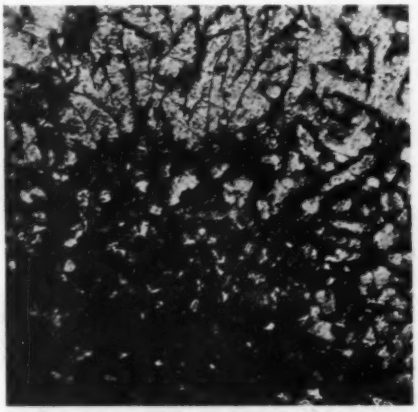


FIG. 2.—BOUNDARY BETWEEN GAS-PENETRATED AREA (DARK) AND UNAFFECTED PORTION (LIGHT) OF P. MAGNIFIED 150 DIAMETERS.

expansion consequent on this chemical change, the earlier members should grow and the later ones should not. It was also obvious that such a series would also test whether growth was proportional to the percentage of silicon. The following table summarises the results of these experiments:—

Alloy.	Percentage Silicon.	Percentage growth on Heating.
N	1.07	15.40
O	1.79	23.46
P	2.96	32.85
Q	4.20	43.9
R	4.83	59.5
S	6.14	63.0

It was quite clear from these tests that silicon was a most important constituent of cast iron from the standpoint of growth under repeated heatings. If the ultimate growths and percentages of silicon are plotted as co-ordinates, a curve is obtained which shows that, broadly speaking, the growth is proportional to the percentage of silicon, although the value for R seems relatively higher than those of the other five alloys. The growths are far in excess of those that could be caused by the conversion of combined into free carbon, which at the outset could not exceed 1.6 per cent. in the case of N. This is quite inadequate to account for the 15.4 per cent. growth found. The same holds even more obviously for alloys O and P. The fact that the two alloys P and S which had been cut from the gate grew more rapidly than the remaining four, which had not, pointed to an agent which had hitherto been left out of consideration—viz., the gas contained in the original casting, and perhaps also the gases in contact with the test-piece in the muffle. The gate of a casting is, as a rule, more "open," and contains more gas than the risers, and the next step in the investigation consisted in testing bars, which were, as far as possible, comparable with one another from the standpoint of their gas content. Accordingly, another set of bars was machined, each test-piece being taken from the top of a riser; that is, as far as possible from the gate. This series is indicated with double letters, except in the case of O, which is marked with a triple letter.

Effect of Contained Gases.

These samples grew under heat treatment, and reached approximately the same ultimate growth as did the corresponding members of the previous series,

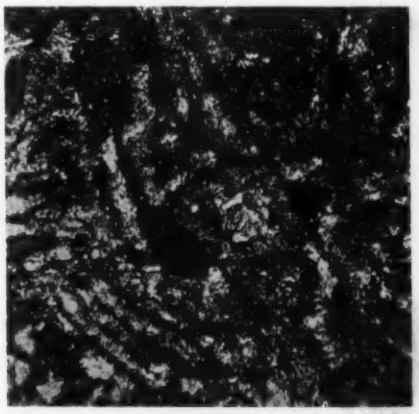


FIG. 3.—GAS-PENETRATED AREA OF P. MAGNIFIED 150 DIAMETERS.

but the rate of growth was in all cases slower. Cracks did not develop in QQ and RR until after the eighteenth heat, as compared with twelve heats in the single-letter series. But the most marked difference was shown by SS, which did not develop cracks until after the eighteenth heat, whereas S cracked after the first heat. Further, although SS cracked extensively before ultimate growth was reached, the cracks never became so large, nor was the specimen as much deformed. These results can be most simply explained by supposing that the castings contain their dissolved gas unevenly distributed, the gate containing the maximum and the top of the riser the minimum, and that the disruptive effects noticed in S were due to an excessive amount of dissolved gas. It was further observed that the end of a sample nearest the gate always grew more rapidly during the earlier heats than the other end, but that ultimately the end furthest from the gate caught up and sometimes passed it. The more rapid growth of the end nearest the gate is explicable on

the above supposition—viz., as being due to a larger amount of dissolved gas. It was the fact that the other end ultimately caught up and sometimes passed it which led us to attribute this to the action of gases in contact with the specimens in the muffle. The following table enables a comparison of the ultimate growths of the two series to be made with each other, and also with the percentages of silicon they contain: —

Percentage Silicon.	Percentage growth on Heating.			
1.07	N	15.40	NN	16.80
1.79	O	23.46	OOO	24.60
2.96	P	32.85	PP	34.40
4.20	Q	43.9	QQ	41.6
4.83	R	59.5	RR	55.3
6.14	S	63.0	SS	61.0

Although, as has been mentioned, the double-lettered series grew more slowly than the previous one, the final results are not only of the same order of magnitude, but on the whole in good agreement, particularly in the cases of the first three members where greater accuracy of measurement was possible. From the two series of tests we drew the following conclusions: —

1. In a series of cast irons of approximately constant carbon the ultimate growth after repeated heatings is, broadly speaking, proportional to the silicon present. This relationship holds up to 6 per cent. of silicon.

2. The growth is far in excess of that which can be caused by the conversion of combined to free carbon, and is, in fact, much the largest in high silicon alloys which contain no carbon combined with iron. (Alloys Q, R, and S.)

3. The behaviour of the alloys on repeated heating, and particularly of Q, R, and S, points to the view that two agencies are at work in their growth—viz.: —

(a) The internal pressure of gas which they contain in their original cast condition, and which is probably chiefly physical in its character.

(b) The effect of external gases in contact with the alloys during their heat treatment, and which is probably partly physical and partly chemical in its nature.

The foregoing bars were not only measured throughout the tests. They were also weighed, and the results plotted with the percentage increase in weight and the number of heats as co-ordinates. The increase in weight follows the same order as the increase in silicon, just as did the increase in volume. There are, however, complications in this case which do not affect the volume changes, and make it more difficult to interpret the "increase in weight" curves.

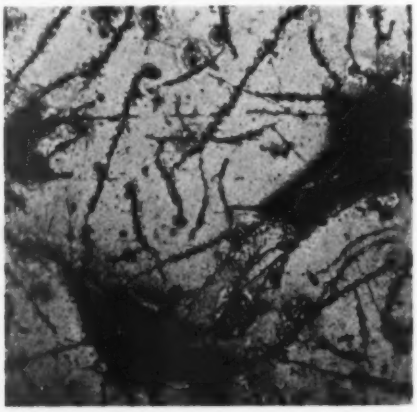


FIG. 4.—SHOWING DEVELOPMENT OF HOLES IN THE INTERIOR OF P. TO WHICH GASES HAVE NOT YET PENETRATED. MAGNIFIED 150 DIAMETERS.

Causes of Growth.

During the heating and cooling of the alloys two causes are at work, one of which tends to increase, the other to decrease, their weight. Later experiments showed that they absorb gases from the interior of the muffle, principally carbon dioxide, carbon monoxide, and nitrogen. The two first-named gases tend to oxidise the silicon and carbon in the alloys. The former process, of course, results in an increase, the latter in a decrease in weight. A detailed study of these changes in weight showed us that there was

(*a*) A partial oxidation of the carbon which diminished with increase of silicon and became nil at 6 per cent.

(*b*) A probably complete oxidation of the silicon, originally present as iron silicide, to a mixture of iron oxide with silica.

(*c*) A partial oxidation of the iron uncombined with silicon.

These deductions agree very well with the fact that the fully-grown alloys very largely lost their metallic nature. They sawed more like a piece of chalk than a piece of metal, and their mechanical strength had greatly deteriorated. In the case of alloys R and S it had, in fact, vanished. The similarity of the

FIG. 5.—TYPICAL STRUCTURE OF P. AFTER MAXIMUM GROWTH HAS BEEN REACHED. MAGNIFIED 150 DIAMETERS.

curves showing the increase in volume and those showing the increase in weight is so marked that it is impossible to resist the conclusion that they are casually connected, and that it is mainly the separation of silica and to a lesser extent iron oxide which causes growth.

Mechanism of Growth.

In order to gain some insight as to the mechanism of growth under these conditions, a microscopic study of one of the foregoing alloys—viz., P—was made. A number of sections, about 0.25 of an inch thick, were cut from the original bar, and introduced into the muffle in which the main bars were being heated. From time to time, as the heats progressed, one of these was withdrawn, and in this way a series of sections was obtained at various stages of growth. The results show that as the heats progressed the

alloy absorbed gas, which increased up to about the tenth heat, and after that diminished. The sections were then examined at a magnification of 150 diameters and typical structures photographed (Figs. 1 and 5).

Fig. 1 shows the structure of the original casting. As shown by the chemical analysis, the greater part of the carbon is present as graphite (seen as black lines). The remainder of the field (mottled) shows the solid solution of iron silicide in the residue of the iron, together with a small amount of combined carbon.

Fig. 2 shows a boundary between a gas-penetrated area (dark) and a still unaffected part of the interior (light), in which the graphite plates and the solid solution are clearly seen.

Fig. 3 shows a completely gas-penetrated area in the early stages (after three heats).

Fig. 4 shows the structure of a part of the interior to which the gas has not yet penetrated after three heats. It is a most interesting photograph, because it throws light on changes that take place in the interior of the alloys before the gases penetrating from the outside have had time to make their influence felt. The three large black areas are holes, and the lines distributed through the white areas, although they doubtless correspond to original positions of graphite, no longer represent as much of it. They are for the most part *slits* from which the graphite plates have been removed. The agency in this removal appears to be the gas originally dissolved in the metal, which is probably liberated by heating at the surface of the solid solution in contact with the graphite. The latter is much the weakest mechanical constituent, and it appears to be forced into holes originally present in the casting, which may be, and doubtless are, enlarged by the breaking down of the boundaries between two holes, when these also consist of graphite.

Fig. 5 is typical of the structure of the alloy after maximum growth has been reached. It bears a distinct resemblance to No. 1 in general character, with one important difference—viz., that graphite has vanished from its original position in the form of plates, and the sharp black lines are replaced by blurred markings. The author feels no doubt that these represent areas oxidised by the incoming gases at the temperature of the muffle which pass along the slits caused by the removal of graphite under the influence of the pressure of the originally dissolved gases (as outlined in the previous paragraph).

Although large holes are numerous in the fully-grown alloy, a field free from holes was selected to illustrate the final structure, as it enables the resemblance and the contrast to the original alloy to be most readily seen.

Influence of Furnace Gases.

At this stage of the research it had become abundantly clear that the influence of gases on the growth of the alloys must be closely studied, but one question still remained to be answered before this was undertaken. Although graphite, or temper carbon, had been shown to be present in the alloys that had grown on heating, yet in the nearly constant graphite series, N to S, the growth had been found to be roughly proportional to the silicon present. The question then arose, "Would an iron-silicon series containing no graphite grow on repeated heating?" On testing these alloys for growth on heating, the changes of volume were found to be quite negligible. These results serve to emphasise anew that free carbon in the form of either graphite or temper carbon, is one of the essential factors in the growth of cast irons under heat treatment.

Further experiments showed that the alloy S, when heated to 900 deg. Cent. in vacuo, not only does not grow, but actually shrinks slightly. It is interesting to note that it contracted slightly in length and expanded in width. This alloy grew 62 per cent. (mean value) when heated to constant volume in a muffle in contact with gases. There is, accordingly, no doubt but that the growth is caused by gases. A further important conclusion can be drawn—viz., that the gas contained in the alloy cannot have any appreciable effect in causing growth, otherwise there would be a permanent growth in vacuo. The cracking of S and SS was shown to be due to pressure from within caused by the dissolved gases hydrogen and nitrogen (their co-efficient of expansion at the ordinary temperature is about 400 times greater than that of grey cast-iron), and their rapid growth is due to the relatively large surface thus exposed to the penetration of the muffle gases. Nearly half the total quantity of penetrating gases was shown to consist of the oxides of carbon. These are responsible for the oxidation of the iron silicide, which is so closely bound up with the growth of the alloy.

Summarising the results obtained, it may be said that there are alloys, *e.g.*, S, whose growth in air is due entirely to oxidising gases penetrating the interior, and others, *e.g.*, N, where this may not be the sole agent, but where originally dissolved gases contribute to some extent to the growth.

Effects of Phosphorus, Sulphur and Manganese.

There still remained to be considered the effects of phosphorus, sulphur, and manganese on growth. They can be summarised as follows:—Phosphorus not only does not cause an increase in ultimate growth, but a marked diminution—viz., between 2.5 and 4 per cent.—for corresponding irons. Moreover, it retards the rate of growth and renders it rather more regular. After examining a large number of typical analyses of commercial grey irons, it appeared unnecessary to undertake any special experiments as to the effect of sulphur. The amount present is invariably small, rarely reaching 0.2 per cent. Taking this into consideration, together with the tendency of sulphur to keep carbon in the combined state in irons, it is quite certain that this element does not contribute appreciably to growth. If anything, its influence is in the opposite direction. Manganese is a most important constituent. Experiments have shown that in all cases it retards the rate of growth, and in the majority of cases it diminishes the absolute amount.

Having determined the specific effect as far as possible of the various constituents in cast irons on growth, we are now in a position to consider their combined effect on any particular iron. In doing so, however, we must regard them not as has hitherto been done for the sake of simplicity, as chemical elements, but in the forms in which they really are present as structural entities.

In the first place, silicon is present as a solid solution of iron silicide, and possibly manganese silicide in iron. This may be called "silico-ferrite." Taking everything into consideration, and having regard to the fact that the great majority of commercial grey irons contain between 1 and 3 per cent. of silicon, this constituent, "silico-ferrite," must be regarded as by far the most potent influence in causing growth. Carbon may be present in two forms:—

(1) Free, as graphite or temper carbon. This form is essential to growth, but its action is indirect. It does not actually contribute to growth, but merely acts as the channel by which gases penetrate into the iron.

(2) Combined, as iron carbide or as iron-manganese carbide, according to the amount of manganese present. This is only a slight contributory cause of growth, and at the very outside is not responsible for more than 1.6 per cent.

Phosphorus present as phosphide eutectic, and manganese present probably in more than one combination, not only do not contribute to growth, but diminish to a notable extent both the rate and the absolute amount.

Finally, dissolved gases, consisting principally of hydrogen and nitrogen, are important factors in the growth of "close" grey irons, but not of "open" ones. Their influence is most powerful when the silicon does not exceed 1 per cent., and in such cases they may cause a growth of 10 per cent. Between 1.75 and 3 per cent. of silicon they may be responsible for growths of 1 or 2 per cent. Above this their influence appears to be nil.

Possible Remedies.

I wish to state at the outset that the foregoing investigations have led me to the conclusion that there is no such thing as a grey iron which will not grow, either when repeatedly heated to redness, in contact with furnace gases or air, or with superheated steam, unless an enamel can be found which has the same co-efficient of expansion as the iron, and which will adhere at all temperatures likely to be realised in practice, thus constituting an effective buffer between the gases and the graphite slits.

The root of the trouble is not the silicon, which by itself, as I have shown, does not cause growth, but the free carbon, which has no direct connection with it, merely acting as the channel for the gases penetrating to the silico-ferrite. It appeared to me, therefore, that the best chance of solving the difficulty was to find an alloy that would fulfil industrial requirements, and which not only contained no free carbon, but would not deposit this on repeated heating. In the first instance attention was turned to the alloys with which the first experiments had been made—viz., the white irons containing only iron and carbon. It will be remembered that so long as they remained white, and 8 out of 9 did so, they not only did not grow on repeated heating, but actually contracted slightly. I may say that with one exception—viz., one of the pure iron-silicon alloys—my investigations have not resulted in the discovery of any alloy whose volume is absolutely unaltered after repeated heatings. Either there is growth or shrinkage. It may be very slight, but it is none the less there. For practical purposes, however, I shall assume that a variation in volume of not more than 0.5 per cent. is permissible. Most of the iron carbon alloys with which I experimented fulfilled this requirement, and accordingly, in the first instance, I suggested that the most suitable composition for a non-growing cast iron was one of 3 per cent. carbon and as few impurities as possible. Of these silicon being much the most important, the limitation to 0.3 per cent. appeared desirable. This recommendation was criticised on two grounds. It was pointed out that commercially it would be difficult to obtain an iron with so low a percentage of silicon, and that 0.5 per cent. was the minimum practicable figure. Further, it was urged that owing to the pronounced crystalline structure of such castings, the crystals arranging themselves at right angles to the cooling surfaces of the mould, they would be certain to crack on heating. In deference to these criticisms, which are well-founded, I have turned my attention to other alloys, but before leaving this alloy I should like to say that there is certainly one foundry in this country where chill moulds are successfully used, the composition of which is by no means far from that which I have recommended.

It then occurred to me that an alloy containing the lowest carbon of the series of pure iron carbon alloys that we investigated, and which is in reality a mild steel, had several points in its favour. Its composition is as follows:—

Carbon	0.15	per cent.
Silicon	0.186	,,
Manganese	0.15	,,
Sulphur	0.040	,,
Phosphorus	0.017	,,

It is very ductile material, and it hardly changes in volume on repeated heatings. I have been informed that a mild steel of this type has been successfully used for annealing ovens and has not grown appreciably. It has also been used with complete success for high-pressure steam valves and turbine castings, but owing to its high melting point it is a good deal more expensive than any cast iron. Although this particular alloy was made from pure Swedish irons, there is no reason why English irons should not be used, even though they are higher in impurities. Ordinary English mild steel would do quite well. At high temperatures, however, this material loses its mechanical strength, and it would be unsuitable for such purposes as grate bars. I think this difficulty could be met to some extent by increasing the carbon up to, if necessary, 1.5 or even 2 per cent. This would give a more fusible, and therefore cheaper alloy, and one which is much stiffer at a red heat. I think there is an opening for what I may call very hard steels of this type.

Coming back to what I may call the region of cast iron, I found a hint from Mr. J. E. Fletcher, of Dudley, very useful in setting me on the track of alloys which held out some promise of success. I had found that manganese retarded the rate of growth in all cases and diminished it in the majority of cases. So does phosphorus. But whereas the latter renders the cast iron brittle, he found that manganese toughens it to an appreciable extent. Taking all the facts into consideration, it appeared that the influence of manganese should be more thoroughly investigated, and that alloys containing about 2.5 per cent. of carbon, 0.5 to 0.6 per cent. of silicon, and varying amounts of manganese, might be expected to furnish one of very small and perhaps negligible growth, and of sufficient toughness.

Three alloys were ordered from Sir W. G. Armstrong, Whitworth & Company, the actual compositions being as follows:—

	No. 1. Per cent.	No. 2. Per cent.	No. 3. Per cent.
Carbon	2.40	2.40	2.25
Silicon	0.485	0.471	0.406
Sulphur	0.01	0.01	0.01
Phosphorus	0.01	0.01	0.01
Manganese	0.51	0.735	0.935

The turner who machines the specimens reported that "they turned like very tough malleable irons." No. 1 contracted for about eleven heats, then grew fairly regularly until the 76th heat, and afterwards contracted slightly. At heat No. 126 its growth was 5.35 per cent., and then a further growth set in. After 151 heats its growth was 7.49 per cent., and was not yet finished. No. 2 behaved somewhat similarly, but grew less, 6.06 per cent. growth being recorded after 151 heats. No. 3 grew very markedly less than Nos. 2 and 1. After 100 heats its growth was only 1.61 per cent., and after 151 heats only 3.09 per cent. It will further be observed that the growths are in the inverse order of manganese contents.

Finally, an alloy was cast by Sir W. G. Armstrong, Whitworth & Company, at my request,

the following table giving the composition asked for and actually obtained:—

	Desired Composition. Per cent.	Composition obtained. Per cent.
Carbon	2.50	2.660
Manganese ..	1.50	1.640
Silicon	0.50	0.587
Sulphur	0.01	0.01
Phosphorus ..	0.01	0.01

The tensile test of this alloy gave 22.41 tons ultimate stress. The turner reported that this alloy also machined like a very tough malleable iron. This alloy contracted very slightly but steadily for 75 heats, the amount then being 0.39 per cent. Afterwards the contraction also diminished very slightly, and after 151 heats it was found to be 0.13 per cent. So far as these conditions are concerned, therefore, it may be claimed as an alloy which does not grow at all after repeated heatings, but, on the contrary, undergoes a slight shrinkage, which at no time amounted to 0.4 per cent.

In view of the rapid deterioration of the mechanical properties undergone by grey irons during growth, it was considered most important to test bars Nos. 1—4, after their prolonged and repeated heating. They were accordingly machined to 0.564 of an inch, and broken in the testing machine with the following results:—

Bar No.	Original Bars.		Bars after 150 heats.	
	Ultimate Stress.	Fracture.	Ultimate Stress.	Fracture.
	Tons per sq. in.		Tons per sq. in.	
1	19.92	Platey	17.00	Close dull grey, almost non-metallic.
2	20.20	,,	21.92	Lighter grey, more metallic.
3	22.00	,,	*25.68	Lighter grey, more metallic.
4	22.41	,,	*24.69	Very light grey, most metallic.

* These figures would have been even hi her had the bars not ractured in the screw-head.

The above results are very important and remarkable. No. 1 shows a diminution in tenacity of 2.92 tons, but is still good. No. 2 shows an increase of 1.72 tons, while No. 3 shows an increase of no less than 3.68 tons, and, as explained at the foot of the table, this must be regarded as a minimum increase, and lower than the probable figure. Most important of all, No. 4, the non-growing bar, shows a rise of 2.28 tons, which must also be regarded as a minimum figure. Its tenacity is thus markedly improved by treatment, which invariably causes a deterioration of that of the grey irons. From the practical standpoint, no result of higher utility could have been obtained.

The experiments have shown that in order to obtain on this basis an alloy whose growth on repeated heating is negligible, about 1.5 per cent. of manganese must be present. This alloy melts at 1,346 deg. C., a figure which is almost identical with the melting point of a No. 1 Hematite pig-iron containing 4.2 per cent. total carbon, that I recently have had occasion to determine.

I may say that from a practical standpoint there is no reason why the sulphur and phosphorus should be as low as 0.01 per cent. They could quite well be raised to 0.05 per cent. each, figures which would bring them within the range of English irons, and lower the melting point to very little above 1,300 deg. C. Such an alloy, therefore, would not be any more expensive to found than the grey irons which are at present used. It is a tough material, turning like "a very tough malleable iron." It possesses a most valuable practical property, viz., repeated heating not only does not deteriorate its mechanical strength as in the case of grey irons, but it actually improves its tenacity, and probably its ductility also. The slight deposition of temper carbon that does take place will certainly not make the material any more brittle.

It appears to me that an alloy of this type might be tried with advantage for annealing ovens, rolls, grate-bars, the grids of muffle-furnaces, high-pressure steam valves and turbine casings, in place of the present grey irons, whose growth is so annoying a characteristic. I think also that it would be worth trying for ingot moulds in an iron foundry. If it is found to be too brittle and to crack on heating, then the carbon and the manganese can be lowered, the former to 1.75 or even 1.5 per cent., and the latter correspondingly. If the iron is not exposed to a temperature higher than that of steam superheats in vogue, I think the carbon could with advantage be dropped to that of any ordinary mild steel, and in that case the manganese could also be lowered to the ordinary figure. But where, as in the case of ingot moulds for iron grate-bars and annealing ovens, the material has to have a considerable degree of strength at high temperatures, this can best be secured by raising the carbon to the figure I have given and rendering the carbide stable by the addition of sufficient manganese.

Discussion before London Branch.

Mr. J. Oswald (Branch President), in proposing a vote of thanks to the lecturer, referred with high appreciation to his research work on iron, and also on the non-ferrous metals and alloys.

Mr. Robinson asked what were the casting properties of the non-growing alloy mentioned by the lecturer. The trouble of growth had been experienced with hardening ovens, but he had deferred it by thickening the bottom of the oven and reversing it. Could the non-growing alloy be cast in a green sand mould, and also what deflection on a 3-ft. test bar did it give?

Mr. Edwards remarked that the annoying trouble experienced with steel ingot moulds through growth had been referred to, but this should not cause trouble provided the surfaces of the mould remained smooth. He would expect the hot metal to bite into the mould if the latter were made of steel.

A Member, touching the point of the use of steel for ingot moulds, which was a familiar feature of German steel-works practice, suggested that the dressing of the mould with compositions of hydro-carbons or other substances accounted for the metal not biting into the mould. He asked the lecturer whether the non-growing alloy mentioned would be suitable for super-heated steam pipe-lines, a class of work in which troubles resulting from growth at the temperature of superheated steam had caused steel to be largely substituted?

Mr. J. W. Horne (Branch Vice-President), in supporting the vote of thanks to the lecturer, expressed his pleasure at listening to the address. The conclusions to be drawn were of incalculable value to foundrymen and engineers, and if carefully considered would cause the engineer to come into closer touch with the foundry, particularly in regard to design. It was for the practical man now to sift the data presented, and put them into actual practice. He hoped that the British Foundrymen's Association would soon be able to realise their intention of voting money for research work along these and other lines.

Dr. Carpenter, replying to the discussion, said he could not answer as to the casting of the non-growing

alloy in green-sand moulds. It was expected that the alloy would be suitable for casting from a crucible. Nor could he give the requested information as to the deflection. Regarding Mr. Edwards' remarks, he (Dr. Carpenter) was under the impression that trouble was certainly experienced with the use of hematite iron for ingot moulds, owing to the face of the mould growing and becoming distorted. As to the biting of the molten metal into steel moulds, if proper dressing was put on these moulds could be used for 250 to 300 casts, and retain the proper shape. For superheated steam fittings, he thought that steel was the better material to employ, as being less likely to give trouble. A difficulty experienced in this country was that irons could not be bought to composition. The logical conclusion of the work he had outlined was that greater attention would have to be paid to composition.

Discussion at Sheffield and District Branch.

THE PRESIDENT, in opening the discussion, said that they were all familiar with the annealing pot, and they could all see its growth by the evidence of their own eyes. It was a matter of inches—several inches sometimes. That growth meant an increase in the porosity of the pan. Many precautions were taken to make the inside of the pan air-tight, but all the time it was permeable to furnace gases.

MR. T. SWINDEN said the paper was one of the most practical from a laboratory that had ever been published. Professor Carpenter had said that silicon was the greatest offender in regard to growth in cast iron. He took it that it was meant that the action of the silicon was entirely through the carbon being transferred from combined to free carbon, and in that case the oxidation of the silicon to silica really did not influence the growth. It was purely the oxidation of the iron, due to the oxide getting in along the places vacated by the graphite. He thought experiments to determine the effect of heating the bars in a reducing atmosphere would be very interesting indeed. It would be rather different to heating the bars in vacuo, where no gases at all were present. It was quite feasible that some growth would take place, because the material would expand with heat, fissures would be made between the middle of the graphite, the gases would tend to penetrate, and it was very questionable whether the bar would regain its original size on cooling down after repeated heatings.

PROFESSOR CARPENTER: What sort of atmosphere do you mean?

MR. SWINDEN: Well, say hydrogen.

MR. L. REDMAYNE said the question appealed to him particularly with regard to annealing pans. Where Professor Carpenter would heat his bars four hours, an annealing pan would perhaps be heated for six days, and there was bound to be a very big difference. He took it that nothing would stand in the annealing pan but white iron. He asked whether Professor Carpenter would recommend 1½ to 2 per cent. of manganese to stop the growth in ordinary local irons. If they were compelled to have Swedish iron, the extra cost would put it out of court straight away.

PROFESSOR CARPENTER: I said that there was no reason why English irons should not be used, with the higher percentage of sulphur and phosphorus which are present.

MR. V. C. FAULKNER said that he had some months ago substituted mild steel channels and firebrick coffins for the old cast iron, and they were meeting with every success. He inquired whether the introduction of silica and ferrous-oxide in the actual ingot mould would result in lowering the melting point?

MR. J. FEASEY asked whether Professor Carpenter considered 1.5 per cent. manganese suitable for engine castings, such as super-heated cylinders and gas-engine castings, where there was very great heat inside and the outside was subject to water cooling. What would he recommend for that internal growth? The inside temperature was a red heat.

MR. ATKIN asked whether the alloy that Professor Carpenter recommended would prevent the fracture of annealing pans after 100 or 150 heatings.

THE PRESIDENT, referring to the Swedish iron difficulty, said ordinary mild steel scrap could be used to pull down the sulphur and phosphorus limits to the level indicated in the lecture. That would bring the material within commercial limits.

PROFESSOR CARPENTER, replying to the discussion, said with regard to Mr. Swinden's first point that he was afraid he did not make himself quite clear in the lecture, owing to a desire to be brief. He certainly thought that the separation of silica from the silicon ferrite caused an increase of growth, but in the same way that the separation of free carbon from dissolved carbon or combined carbon caused an increase. Speaking generally, he believed that the separation of any new constituent on heating would cause an increase in volume, and certainly he regarded the separation of free silica as contributing enormously to growth. He asked Mr. Swinden what he meant by a reducing atmosphere, because they could not regard carbon monoxide as a reducing atmosphere. He had not actually done any experiments in hydrogen, because those did not appear to him to be practical conditions. He did not know of any practical conditions where the iron would be in contact solely with hydrogen. It would, of course, be of scientific interest. He was afraid the manganiferous irons had not got any elongations that were measurable. From that point of view they were a brittle material, but from the point of view of the difficulty of breaking them by methods under which the iron-carbon alloys broke easily, they were certainly a tougher material. As to Mr. Redmayne's point about the length of time of the heats, he found in his tests that if one of his bars was heated for three hours there was as much growth as they got in 17. The condition was practically stationary. It was all a question of getting the material at a given temperature, and after that the length of time did not matter. So that although the difference between four hours and six days sounded long, he did not think it was great when the difference in size was taken into account. He did not regard that as throwing any doubt on the results obtained in his experiments. Mr. Faulkner's reference to mild steel was exactly what he should have expected, from his knowledge of the subject. It was only one of several instances he had known, where mild steel had been found to be free from the evil of growth and cracking. As to the effect of the separation of silica and iron oxide on the fusing point of the iron, it would be in the direction of rendering it more infusible, not less. But the mischief was done when they had got the iron oxide and silica separated—they had got the holes for the fluid material to run into, and the thing was past praying for. He was very loth to answer the questions of the last two gentlemen offhand. He really did not know enough to say. He had been asked a good many questions since he started making recommendations, and he had found that in each practical case all the factors had to be taken into consideration before giving an opinion. But, speaking generally, he should say that supposing the iron with 2¼ per cent. carbon, 1½ per cent. manganese, and ½ per cent. silicon did crack, the remedy was to drop the carbon. They could drop the carbon, and at the same time the manganese. Of course, they increased the cost of production by so doing.

A Small Detachable Open-Hearth Furnace.

In our issue of April, 1909, we published in abstract a Paper by Mr. W. M. Carr, in which the writer dealt with the advantages of the small oil-fired open-hearth furnace for light steel castings. In the course of his investigations, Mr. Carr designed a small furnace of this description, the body of which was cylindrical and entirely separable from the ports. To avoid the trouble with slag in lip pouring, the furnace was fitted with a nozzle and stopper, worked through the charging door and set in place long enough before tapping to permit of heating the stopper fittings. It was proposed, if desired, to carry the furnace to the moulds, pouring directly into them, thus giving a combined melting chamber and pouring ladle.

In the past two years Mr. Carr has brought his small detachable open-hearth furnace into practical operation at the Glenova, W. Va., plant of the Alloy Steel Casting Company, Wheeling, W. Va., U.S.A., of which he is general manager. This plant is described and illustrated in a recent issue of "The Iron Age." The furnaces shown are of one to two tons capacity per heat (as against 500 lbs. capacity in the original experimental furnace) and they are producing steel of a standard quality, the metal being used for automobile parts and general machinery castings of both plain and alloyed steels. The general construction and operation are evolved on the principle of securing on a small scale all of the advantages of the usual large capacity open-hearth furnace with its simplicity of operation, uniformity of product, and the opportunity of complete control. It is known that a volume of steel of one to two tons produced by open-hearth methods involves some little risk in chilling, thereby causing some misruns of castings of light, thin-sectioned parts, as would occur where a ladle is used to transfer the metal from the furnace to the mould. In the newer installation shown the use of the ladle is dispensed with. The furnace at tapping time is lifted away from its port connections and the metal poured directly from it into the moulds. The flow is controlled by the nozzle and stopper fittings referred to above, fixed in place shortly before tapping. In this way the initial temperature of the metal is preserved and small castings are made which heretofore have been considered out of the reach of ordinary open-hearth foundries.

The inventor states that the furnaces can also be used for the manufacture of tool steels of crucible compositions, doing away with the heavy cost of the crucible and producing a metal of high grade, of uniform composition and at a satisfactory casting temperature. The claim of uniformity is based on the fact that the volume of steel being small permits a proper distribution of the various ferro-alloys which may be added to give the different compositions. While definite data as to cost of operation are not given, Mr. Carr says that they are less than those of the small Bessemer process or the crucible process and that the figures compare well with standard open-hearth practice. He gives the following details concerning the practice developed at the Glenova Foundry:

The furnace body being detachable, very little time is lost in the case of repairs, the plan being to have on hand spare lined shells for immediate substitution. The time then saved is a distinct advantage over the usual type of open-hearth furnace, which would be idle during the period of general repairs. In this case the damaged part is removed and immediately replaced with a newly lined one.

The installation of furnaces of this type is best

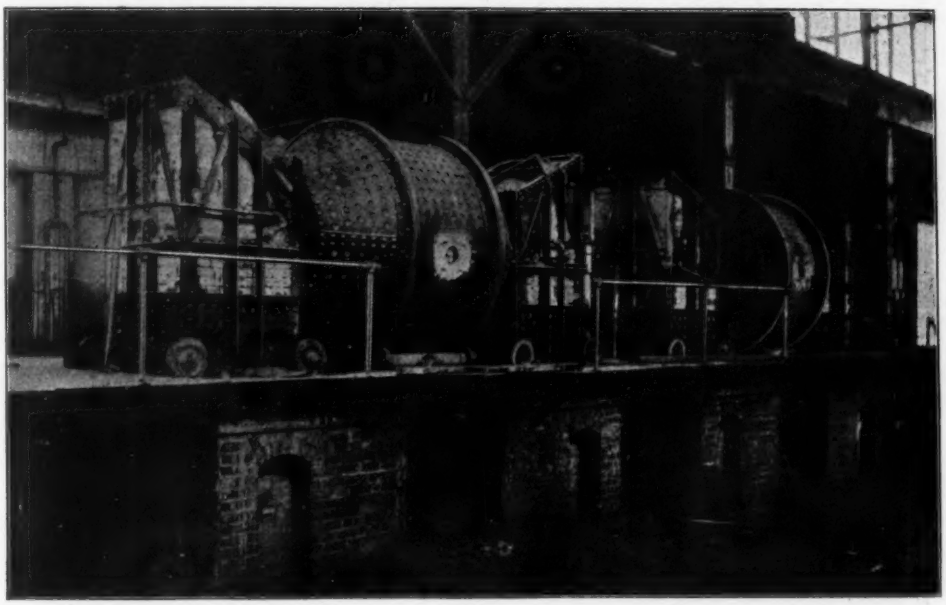


FIG. 1.—FRONT VIEW OF CARR'S DETACHABLE OPEN-HEARTH FURNACE.

adapted to small steel castings and light intermittent tonnages of castings varying from 500 lbs. down to ounces per piece, and in outputs varying from 1 ton to 10 tons per day. This type is also recommended for the manufacture of malleable iron castings of light weights and small tonnages. The advantages claimed may be summarised as follows :—

FIG. 2.—CHARGING PLATFORM OF DETACHABLE OPEN-HEARTH FURNACE.

1. Moderate first cost of installation. 2. Lowest operating costs (excepting only the large capacity open-hearth furnace). 3. Low cost of repairs. 4. Avoidance of skulls and ladle expense. 5. Extremely hot, fluid metal of standard open-hearth composition. 6. Rapidity of operation. The average time of a 2-ton heat is three and a-half hours.

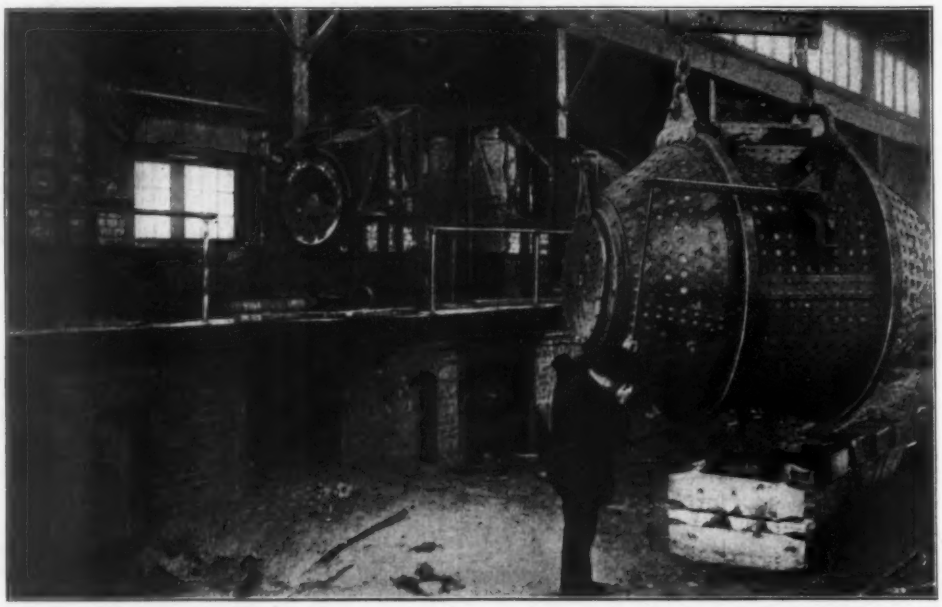


FIG. 3.—A 2-TON DETACHABLE OPEN-HEARTH FURNACE IN CASTING POSITION.

High-Pressure Gas for Metals.

In the course of an address on the subject of "High-pressure Gas," delivered on March 23, before the Midland Junior Gas Association, Mr. E. W Smith remarked that in Birmingham, the greatest increase in high-pressure gas consumption was in connection with metal melting. Ovens and annealing furnaces only required high-pressure gas or air blast when they had to deal constantly with heavy work. Then it was necessary that the furnace should quickly recover its normal temperature after the work had been placed in the furnace. Generally, however, a well-designed low-pressure furnace would do all that was required in annealing and hardening.

For metal-melting by means of gas, the one great necessity was that there should be a constant and reliable supply of British thermal units from the burner. That the melting of metals by means of high-pressure gas on a commercial scale was an economical proposition was proved by the large number of firms in Birmingham who had installed, and were installing, high-pressure gas for metal melting. A gas with a calorific value of about 520 B.Th.U. net appeared to give the best results in furnace work. A richer gas required more air for combustion; and the margin of air injected would be correspondingly cut down. To get the same results with a gas of lower calorific value, a corresponding increase in the volume of gas used would have to be made. In the event of the calorific value being very much reduced, equal results could not be obtained when working under the same conditions, even though the consumption had been increased. With regeneration with such a gas it might be possible; but for straight heating, low-grade gases did not give as good efficiencies as better quality gas—especially for high temperatures.

The latest success achieved in gas heating in Birmingham, continued the lecturer, was in connection with the melting of nickel and manganese bronze.—"High-grade German silver, containing about 25 per cent. of nickel, has been melted commercially for some time, at an average cost of £1 6s. 3d. per ton, with gas at 1s. 3d. per thousand cubic feet. The metal is melted in 84-lb. lots, and each takes about an hour and a-half to run down. The preliminary heating up of the furnace takes about 45 minutes. This cost is included in the figure quoted. The cost to this firm with coke and blast varied between £2 and £3. Ninety-nine per cent. nickel is being melted economically, compared with coke, in high-pressure gas furnaces, by manufacturers in Birmingham. Manganese bronze, which requires a higher temperature than nickel, has been melted on a large scale; and the system will shortly be adopted in works in Birmingham. The fusion of the ferro-manganese used is the most difficult problem we have yet tackled. Common brass is now being melted at a cost for fuel alone, in 60- to 200-lb. pots, averaging 5.5d. per cwt."

FIG. 4.—VIEW OF FOUNDRY FLOOR OF ALLOY STEEL CASTING COMPANY, EQUIPPED WITH DETACHABLE OPEN-HEARTH FURNACE.

SUBSCRIPTIONS have been invited during the month at 98 per cent. for £250,000 6 per cent. first mortgage debentures, and at par for 350,000 preference shares of £1 each of the Argentine Iron and Steel Company, Limited. This concern has been formed to acquire the business of metallurgical workers carried on by Pedro Vasena & Sons, of Buenos Aires. The firm was established in 1870, and the surplus of assets over liabilities to be acquired has been valued at £766,390.

SIR W. G. ARMSTRONG, WHITWORTH & COMPANY, LIMITED, have appointed a "Works Board," which will be competent to deal with departmental questions. The members of it will be styled "local directors." They are all of long service with the company, and well known in the engineering industry. The Committee comprises Mr. Arkwright, Mr. Brackenbury, Mr. Carter, Mr. Cochrane, Mr. D'Eyncourt, Mr. Gledhill, Mr. Hadcock, Captain Lloyd, Mr. Marjoribanks, Mr. Matthews, Mr. Orde, Mr. Perrett, Mr. Spencer, Mr. Saxton White, with Major Lowe as secretary.

The Constitution of Cast Iron.

By W. H. Hatfield.

To the monthly meeting of the Birmingham Branch of the British Foundrymen's Association held on Saturday, March 23, at the Municipal Technical School, a special invitation had been given to the members of the Birmingham Metallurgical Society. The subject for discussion was a Paper by Mr. W. H. Hatfield, of Sheffield, on "The Constitution of Cast Iron; with a few remarks on the Changes taking Place during Heat Treatment." Mr. H. L. Reason, President of the Branch, took the chair and extended a hearty welcome to the members of the visiting Society.

After indicating by lantern-slides the gradual evolution of the blast furnace the lecturer proceeded to discuss the constitution of the product.

Iron, as had been shown, when produced in other times, was relatively pure and was found under the microscope almost entirely to consist of ferrite crystals. The addition of carbon, which resulted in the production of steel, modified the microstructure, which then presented in a normal or softened condition the well-known "pearlite" structure, along with either free ferrite or free cementite, according to whether the steel contained more or less carbon than about 0.89 per cent. Relatively, the ordinary iron-carbon steels present little difficulty, as they form a single iron-carbide system in which the carbide exists in the unhardened condition as massive carbide or pearlite carbide and at high temperatures above the recalescence point as a solid solution of carbide in iron. With the cast irons the problem is rendered more complicated by the large quantities of elements other than iron and carbon which are usually present, such as manganese, sulphur, silicon, and phosphorus. These elements all individually produce definite reactions with iron, and also in some cases with each other, and thus cast irons and pig-irons may present a complex and variable mass of free iron and free carbide, double carbide, sulphides, silicides, and phosphides. Each individual constituent will have its own particular characteristic, its own thermal phenomena, and, what is also very important, its own co-efficient of contraction. One important aspect of the presence of the impurities is that their actual influence is greater than the percentage recorded by analysis would lead one to anticipate. For instance, a cast iron containing from 6 per cent. to 7 per cent. impurities would actually contain 30 per cent. to 40 per cent. of compounds formed therefrom.

Carbon in Cast Iron.

Scientific research in the last decade has clearly demonstrated that metals and alloys in their behaviour during freezing and cooling are very similar to aqueous solutions and fusion mixtures, and cast iron is no exception to the rule. Pig-iron and cast-iron must be considered as a frozen solution of carbon and iron, and if viewed from this standpoint the consideration of the subject becomes simplified.

[The lecturer here discussed the comparative equilibrium diagrams of the salt and water and iron-carbon systems and emphasised the fact that pig-irons are almost invariably of the same composition as the eutectic alloy of the iron-carbon system, the eutectic alloy being that particular alloy of iron and carbon which has the lowest melting point of the series. In the absence of other elements, such an iron will contain in solution at the temperature of freezing 4.3 per cent. carbon, and it is common knowledge that the whole range of pig-iron usually approximates to 4 per cent. in the carbon content. The presence of a fair percentage of other elements considerably influences the solubility, which subject the lecturer dealt with later.]

As a result of due appreciation of existing data it is clear that the iron ore is reduced to iron in the upper regions of the blast furnace, and as the spongy mass of metal descends, carbon is absorbed from the coke; and it will be obvious that iron in contact with a surplus at such high temperatures will rapidly become a saturated solution of carbon, or, to be more accurate, carbide in iron. As this molten iron in the hearth of the blast furnace cools down to solidifying temperatures the carbide in solution in the iron in excess of that required to form an eutectic alloy is thrown out of solution and simultaneously decomposes into iron and carbon, with the production of kish. The iron then freezes, the eutectic alloy of iron and carbon splitting up into carbide and austenite (solid solution). The carbide thus liberated either decomposes or persists according to the prevailing conditions of rate of the cooling and composition of the iron. Further cooling results in the precipitation of further free carbide, which behaves in a similar manner to the carbide separated at and near the freezing point. When temperatures in the neighbourhood of 700 deg. C. are arrived at, the solid solution still corresponds in composition to "hardenite," which on passing through the recalescence at about this temperature resolves itself into carbide and free iron. This pearlite carbide thus liberated will again either decompose into iron and free carbon with the production of perfectly soft pig-iron or will persist and be recognised as pearlite in the final iron.

[The lecturer here, by means of lantern-slides, actually demonstrated the fact of the production of graphite during and immediately after the freezing point.]

Silicon in Cast Iron.

The influence of silicon in cast iron is twofold. First, when added to iron it materially affects the solubility of the carbon. This is clearly indicated by the following table, which summarises the result of the research conducted by Wüst and Petersen :—

No. of Test.	Si. per cent.	Total Carbon of Eutectic.	Freezing Point Deg. C.
1	0.13	4.29	1138
2	0.21	4.23	1131
3	0.66	4.05	1152
4	1.14	3.96	1155
5	1.41	3.88	1160
6	2.07	3.79	1175
7	2.68	3.56	1185
8	3.25	3.41	1187
9	3.69	3.32	1197
10	3.96	3.24	1205
11	4.86	3.08	1210
12	5.06	2.86	1215
13	13.54	1.94	1233
14	18,76	1.19	1240
15	26.93	0.87	1255

It will be seen on reference to the table that the eutectic alloy which in the absence of silicon contains 4.3 per cent. carbon is considerably modified, and that at what is a frequent commercial percentage of silicon, viz., 3 per cent., the carbon percentage

of the eutectic is reduced from 4.3 per cent. to 3.4 per cent. Secondly, the main influence is in its tendency to cause the carbon present in the iron to be found as graphite in the final pig or casting. Turner's research, conducted many years ago, clearly demonstrated how by gradually modifying the percentage of silicon contained in the cast iron, the physical properties could be influenced by the indirect action of the silicon in modifying the condition of the carbon.

The influence of silicon is, however, greatly modified by works conditions, the chief of which are :— (1) The size of the casting. (2) Rate of cooling. (3) Casting temperature. The size of the casting is the paramount consideration, and naturally other conditions being equal, determines the rate of cooling. Take, for instance, a small test bar containing silicon, 0.80 per cent.; most likely the test bar would contain over 1 per cent. combined carbon, whilst if a solid lump of a few tons be cast from the same iron it would no doubt be rather difficult to find much combined carbon present. Whereas the microstructure of the test bar would be found to contain cementite and pearlite, the large mass would no doubt in microstructure be found to consist largely of graphite embedded in ferrite. With regard to the rate of cooling, that is naturally an important phase since it means the subjection of the casting to longer periods at higher temperatures, which conditions naturally assist the precipitation of the carbon. With regard to casting temperatures it has now been clearly demonstrated that the higher the casting temperature the more combined carbon is there likely to be in the final casting, the exact explanation of which fact is a question of theoretical reasoning. The silicon present in ordinary cast iron is usually present as silicide of iron.

Phosphorus in Cast Iron.

The presence of phosphorus in cast iron, as in the case of silicon, reduces the solubility of the carbon, and the result is that irons which are very high in silicon and phosphorus generally contain a less total carbon than the pure irons. This will be patent to anyone who examines a collection of analyses of various pig-irons. The action of phosphorus upon the actual condition of the carbon would appear to be very little, and the distinct advantage lies obviously in the low melting points of such irons. To anyone who has melted phosphoric foundry iron and hematite grey iron in a cupola, this feature is well known. Small castings can very well be cast at lower temperatures, and with lower coke consumption with irons containing 1 per cent. phosphorus than in the case of almost phosphorus-free iron. Wüst has demonstrated in this direction that the actual point of solidification of cast iron is actually lowered 27 deg. C. by the addition of each 1 per cent. phosphorus until 6.7 per cent. is reached. The disadvantage of the presence of phosphorus in pig-irons is that the irons produced are more brittle and have less strength. This is explained by the structurally-free phosphides invariably present in such material. The already weakened conditions of foundry irons owing to the weakening effects of the numerous graphitic plates almost obscures this influence of the phosphide.

Influence of Sulphur in Cast Iron.

Sulphur as found in foundry irons usually exists as manganese-sulphide, and as such may practically be ignored, as its action is neutral. If, however, iron contains no, or little, manganese, and sulphur in considerable quantities, the iron is hardened owing to the carbides having persisted down to low temperatures. The actual manner in which the sulphur causes the carbon to remain in the combined state has been the subject of much experiment, but as yet the question is hardly solved. It has been suggested that the sulphide films prevent the segregation of the carbide and thus help to render the carbide stable; but it has also been claimed that sulphur is actually to be found in the carbide, and that its action is of a chemical nature.

Manganese in Cast Iron.

The influence of manganese must be considered from two standpoints. In the first place it neutralises any sulphur present; in the second place it has a distinct influence, when present in large quantity, upon the condition of the pearlite. When normal percentages, such as are found in usual foundry irons, are considered, its influence may be practically ignored. Coe and Wüst have shown the addition of manganese materially affects the pearlite change point by depressing and diminishing it until with 5 per cent. to 10 per cent. manganese the change does not take place, the solid solution from which pearlite is formed persisting right down to normal temperatures. This, whilst of scientific interest, hardly affects foundry practice.

Special Elements.

With regard to the influence of special elements, it may be mentioned that vanadium and chromium when added to cast iron result in increased hardness and strength, but it is doubtful whether the increased physical properties thus obtained cannot be equally well obtained by proper regulation of the ordinary constituents. The elements aluminium and nickel both have a tendency to soften the iron by assisting in the precipitation of free carbon. Titanium is supposed to have a beneficial effect, but so many advantages are claimed from its use that the matter should be carefully investigated. No doubt it acts as a deoxidiser, but any other beneficial influences are doubtful. The influence of other elements requires investigation.

Heat Treatment.

The lecturer by means of a number of lantern slides showed the influence of heat treatment upon both grey and white cast irons.

With regard to grey cast iron, he pointed out that the object was mainly—

(*a*) To relieve internal strain set up by the crystallisation produced during the freezing of the iron.

(*b*) To soften the casting by decomposing any combined carbon present.

As pointed out, the annealing of grey cast iron unavoidably leads to the weakening of such material. As cast it usually consists of a mass or matrix of ferrite or silico-ferrite, more or less strengthened by pearlite which is cut up and weakened by numerous graphitic plates, not to mention the phosphide constituent usually present. If the silicon content is low, it is not unusual to find cementite carbide membranes, which also will be found to assist the strength. A comparatively short exposure between 750 and 800 deg. C. is quite enough in foundry mixtures to completely soften, or, in other words, to precipitate any combined carbon present, and the result of such heat treatment is that the microstructure presented is one of silico-ferrite cut up by swollen plates of graphite. Whereas such castings as cast will have a tensile strength of anything from 9 to 16 tons, after annealing and the breaking down of the combined carbon, they will only give a maximum stress of, say, 3 to 5 tons. It was pointed out, therefore, that whilst annealing will soften such irons, at the same time it materially depreciates their mechanical properties.

Heat treatment of white cast iron practically means the malleableising process. White cast iron as demonstrated, when seen under the microscope, consists of cementite-carbide and pearlite. The object of heat treating such material is to decompose both the cementite and pearlite, with the production of annealing carbon. If this operation is successfully conducted a material is obtained consisting of ferrite in which nodules of the free carbon are to be observed. Such material compares very favourably with wrought iron, and is extremely ductile. The lecturer then proceeded by means of lantern slides to indicate the influence of various compositions and temperatures upon heat treatment, and then discussed the two types of malleable iron now produced, viz., Réaumur and "Black-heart."

Discussion.

Professor Turner said that Mr. Hatfield had expressed his views in a very clear and simple manner. He had just had placed in his hands a copy of Mr. Hatfield's book, "Cast Iron in the Light of Recent Research," and he would advise anyone who had not seen that book to get it. It was a very faithful and fair account of work done recently, and dealt effectually with some difficult controversies. As to the line Mr. Hatfield had taken with reference to the existence of carbide of iron in white iron, and the decomposition of that carbide for the production of graphite, the question was, whether carbide went into solution as graphite and came out as graphite, or went into the solution as carbide and came out as carbide, and then decomposed into graphite. That was a thing not very easy to determine. It was a subject on which they had been conducting some researches at the Birmingham University for a considerable time. There were some men of considerable importance and authority and experienced in foundry work, who took a view exactly opposite to that advocated by Mr. Hatfield. They believed that carbide dissolved in iron just in the same manner as sugar dissolved in water, and came out again in the same manner. He (Professor Turner) believed that they were wrong, and that Mr. Hatfield was quite right. It had often been brought forward that the properties of cast iron depended very largely upon the character of the graphite—upon the quantity and the description of the graphite.

Mr. A. H. Hiorns remarked that particularly the latter part of the Paper, in which Mr. Hatfield gave a *resumé* of his recent researches, was very valuable to them. He was surprised at the remark regarding manganese. Perhaps Mr. Coe would be able to say something on that subject, but he (Mr. Hiorns) certainly doubted very much whether 1 per cent. of manganese had absolutely no influence on the physical properties of cast iron. He had no doubt that perhaps up to 1 per cent. manganese would make very little difference to the microstructure. But there were many parts of the microstructure which were hidden to them, and a good deal of what they thought about the matter was mere guess-work. They did not really know what the composition of the ferrite containing manganese was; to a great extent they could only guess at it. With that one exception he would say that having studied the subject himself, he perfectly agreed with all that Mr. Hatfield had brought before them.

Mr. T. Vaughan Hughes said that with regard to the condition of the carbon, as shown by the microscope, and its amount as shown by analysis, the results given by Mr. Hatfield, in which the carbon content, as revealed by analysis, was practically identical, suggested that the mechanical properties depended upon the condition of the carbon. From a practical point of view, that was only a further demonstration of the fact that, as far as analysis of cast irons was concerned, especially when they had been subjected to any form of heat treatment, the condition in which the carbon and, doubtless, the other constituent were found in the resultant product, was a paramount matter. This was useful, because it had become almost an everyday practice to give analyses of the purity without any reference at all to the state of the carbon in a malleable-iron casting, proving that a microscopical, as well as a chemical, examination was indispensable. Another point to which he wished to refer was the fact that when a material contained about 3 per cent. of carbon it was plainly cast-iron, but when, by the heat treatment to which it had been subjected it had become very ductile, it was practically a wrought iron, and capable of being utilised for many purposes for which cast-iron proper was utterly inappropriate. This brought him to the question of heat treatment. As far as the work he had been doing during the last ten years was concerned—he was referring to matters of constructional work—the heat treatment had been applied to a great many machine accessories, with which, he presumed, many of them were not acquainted. For instance, he knew that castings had been made for crankshafts and so on, which had been submitted to the turner, practically rough-finished, and then, after heat treatment similar to that described by Mr. Hatfield, converted into a species of mild steel. These were re-carbonised on the surfaces intended to withstand wear and tear, that is case-hardened, then polished. Thus an iron casting displaced a mild-steel bar or forging. He mentioned this very interesting fact to indicate improvements that had taken place as the result of the application of the scientific principles underlying suitable heat treatment.

Mr. H. I. Coe said he was interested in Mr. Hatfield's remarks relative to the separation of graphite in cast-iron, and although not quite certain of its indirect formation from iron carbide, thought there was strong experimental evidence bearing out the author's views. From micro-sections of some mottled irons he (Mr. Coe) had examined, iron carbide appeared to separate first, followed by its decomposition in the semi-fluid liquid into spots of graphite, which afterwards appeared to coalesce to form flakes of graphite before solidification was complete. Mr. Hatfield had referred to some published results of his (Mr. Coe's) with regard to the influence of manganese on cast iron; but it must be borne in mind that the base of that particular series of experiments was a Blaenavon hematite iron containing 1 per cent. of manganese, and although further addition of manganese up to 3 or 4 per cent. to that particular iron did not produce any appreciable difference in its properties, later work of the speaker's showed that many striking results were produced by the addition of small quantities of manganese (up to 0.5 per cent.) to a siliceous cast iron.* Mr. Hatfield had shown an exceedingly interesting result by means of his lantern slides; namely, that in a white iron quenched from 1,000 deg. C. the temper carbon produced after subsequent annealing was much finer and more regularly distributed than that produced from an unquenched white iron. That experiment was well worth noting by malleable-iron founders. In conclusion, he wished to ask Mr. Hatfield what were the conditions he employed to obtain a white iron containing 1.88 per cent. silicon?

Mr. R. Buchanan said that he was discussing this question of the graphite in cast iron the preceding

* H. I. Coe, British Foundrymen's Association, January 1911 "Manganese in Cast Iron."

Thursday evening in Keighley. The question with which he was concerned was not whether the graphite went in directly or whether it formed carbide, but the fact that it did go in and come out under certain conditions. There was a difficulty which presented itself to his mind. He thought it had been clearly shown by one authority that it was the carbide which was split up when the graphite was formed. But there was another point. It was quite possible when running a casting to have free carbon come out. He had a square block of carbon which was part of one 12 or 14 in. long that was left in the runner of a large casting. The difficulty that presented itself to him in that case was, how did that carbon come out, seeing that during the period when it came out the iron was not at that point of temperature at which the carbide got resolved again into its constituents. The thing, perhaps, was explicable, but it was not clear to him. The block was 3 or 4 in. square. There was a little core of metal about the size of a man's little finger, which was all the metal left in the down runner. The casting was quite successful. This inner core of metal being drawn out left a core of carbon with no iron in it.

Mr. G. Hailstone agreed practically with all that Mr. Hatfield had said, but there were one or two points he would like explained. Mr. Hatfield gave them on the screen, not only the analysis of the pig-irons, but also the analysis of the separated carbides from these two pig-irons, and showed that manganese was present when they had the highest carbon. He could quite understand the reason why the manganese should exist in the carbide of iron, but the curious thing about it was that there could be 1 per cent. of silicon in the carbide of iron; did it exist as a solution of the carbide of iron, or was it carbide of silicon? They had always been told that under ordinary furnace conditions, carbon of solution could not be produced. With reference to the separation of carbon from commercial irons, taking, for instance, the grey irons, he thought that a great deal of that carbon separated out, as Mr. Buchanan said, before it got to the eutectic mixture. The reason for that, he thought, was supersaturation, the elements present in that iron being in such amounts that the iron could not hold at the eutectic point the amount of carbon which it held in suspension.

Mr. Buchanan remarked that in view of what Mr. Hatfield had said and the general ideas on the subject, he would like to know, when the iron was supersaturated, what condition the carbon was in which formed super-saturation. Was it present as carbide, or was it present dissolved in some other form? Because, although it was super-saturated, it must be held in some condition. He would like to know more exactly what super-saturation meant.

Professor Turner said that the temperature of the decomposition of carbide, as recorded by the pyrometer in their experiments on expansion and so on, was a minimum temperature of decomposition. The decomposition might take place at higher temperatures, at a temperature of 200 deg. or 300 deg. higher than that point, but it would not take place below that point.

Mr. Hatfield, in his reply, said that he was personally actively engaged in manufacturing castings, and what he had told them was all practical, and he would like them to be thoroughly interested in it. The point mentioned by Mr. Hiorns with regard to manganese was not quite settled, although that gentleman's view as to the carbide was proved by what he (Mr. Hatfield) had shown them. When he mentioned manganese in the sense referred to he was speaking of grey foundry iron. Now the manganese neutralised the effect of sulphur and a proportion of the manganese was disposed of in that way. In such irons there was usually a good quantity of silicon present, and from his own experience with foundry iron containing say 2.5 per cent. silicon, 1 per cent. phosphorus, and 0.5 to 1 per cent. manganese, the manganese then, apart from the effect on the sulphur, did not affect the mechanical properties one iota. That was demonstrated by Mr. Coe's experiment published in a Paper which was read before the Iron and Steel Institute, in which he (Mr. Coe) showed that the combined carbon which was the determining factor of the properties of cast iron, was not affected by the presence of manganese.

Mr. C. Heggie: Suppose there is this 0.5 per cent. manganese, and you had sufficient to give, say, 0.6 per cent. when you have finished casting, do you think it would have any influence on the mechanical properties of the iron?

Mr. Hatfield: Not in an ordinary grey iron, provided there was not an excess. Test bars of different alloys containing manganese might be found differing in the mechanical properties, but most probably this would be due to the influence of casting temperature or some other factor. He believed the quantity of manganese specified by Mr. Heggie when added to foundry iron would not affect the mechanical properties of the material. Mr. Hughes was perfectly correct in saying that if one analysed the casting and found a certain percentage of carbon, that in itself meant little. It was something important gained to know that they had it there, but until they saw the microstructure it meant very little. With regard to Mr. Hughes' request for the heat treatment of the test bars of malleable cast iron which gave such excellent tests, he would very much like to go into the question, but at some other time. He was very much interested in what Mr. Hughes said about the case-hardening of cast iron, but it must be borne in mind that in malleable cast iron there was a good deal of free carbon; it was there in the free state, and if the iron were brought to high temperatures immediately the carbon would re-enter into combination. If what occurred were properly investigated it would be found that whilst the outside section was recarbonised, a good deal of combined carbon would also be found in the centre.

Passing on to comment on Mr. Coe's remarks, Mr. Hatfield said that the question of the graphite-austenite eutectic was already disposed of if his (Mr. Hatfield's) statement as to the carbide-austenite eutectic was accepted. He thought he had demonstrated that the eutectic first broke up into carbide and solid solution, previous to the deposition of free carbon or graphite. With regard to Mr. Buchanan's remarks about the piece of carbon found in a runner which he described, he (Mr. Hatfield) would explain the occurrence somewhat on the following lines: There were conditions under which one introduced into the iron more carbon than was necessary to form the eutectic. Now, if such iron were poured into a casting, the iron being supersaturated with carbon, the carbon of supersaturation, which he would say was in solution as carbide, came out of solution upon cooling, decomposed, and the eliminated carbon floated to the top. Still he would like to see the piece before giving a definite opinion about it, but he thought it might probably be accounted for in the way he had mentioned. Coming to Mr. Hailstone's question as to whether the carbide containing silicon contained it as carbide of silicon he would only say that that was further than they had got at present. He had established that the silicon did exist in the carbide, although he rather doubted this being present as carbide, but his opinion was that the silicon was in solid solution, whether as carbide or as silicide he could not say.

Specifications for Motor-Car Steel.

At the annual meeting of the American Society for Testing Materials, held at New York on March 28 and 29, a number of additional proposed standard specifications were submitted, among them being one offered by Committee A-1 covering motor-car carbon and alloy steels. It comprises eight classes, according to chemical composition. They are all tabulated below except that for motor-car nickel-vanadium steel, which was not submitted at the meeting. It was decided to refer the specifications to the members for ballot by letter.

Motor-car Carbon Steels.

Phosphorus, not over 0.04; sulphur, not over 0.045; and carbon and manganese as here tabulated. All values expressed in per cent.

Carbon		Manganese	
Desired.	Permissible Range.	Desired.	Permissible Range.
0.10	0.05—0.15	0.45	0.30—0.60
0.15	0.10—0.20	0.45	0.30—0.60
0.20	0.15—0.25	0.65	0.50—0.80
0.25	0.20—0.30	0.55	0.40—0.70
0.30	0.25—0.35	0.65	0.50—0.80
0.35	0.30—0.40	0.65	0.50—0.80
0.40	0.35—0.45	0.65	0.50—0.80
0.45	0.40—0.50	0.65	0.50—0.80
0.50	0.45—0.55	0.65	0.50—0.80
0.60	0.55—0.70	0.65	0.50—0.80
0.80	0.75—0.90	0.35	0.25—0.50
0.95	0.90—1.05	0.35	0.25—0.50

Motor-car carbon steel screw stock: Carbon, 0.14 (0.08—0.20 permissible range); manganese, 0.55 (0.30—0.80 permissible range); phosphorus, 0.12; sulphur, 0.06—0.12.

Motor-car Nickel Steels.

Manganese, 0.65 (0.50—0.80 permissible range); phosphorus, not over 0.04; sulphur, not over 0.04; nickel, 3.5 (3.25—3.75 permissible range); and carbon, as below. All values expressed in per cent.

Desired Carbon.	Permissible Range.	Desired Carbon.	Permissible Range.
0.15	0.10—0.20	0.35	0.30—0.40
0.20	0.15—0.25	0.40	0.35—0.45
0.25	0.20—0.30	0.45	0.40—0.50
0.30	0.25—0.35	0.50	0.45—0.55

Motor-car Nickel-Chromium Steels with Low Nickel.

Manganese, 0.65 (0.50—0.80 permissible range); phosphorus, not over 0.04; sulphur, not over 0.04; nickel, 1.25 (1.00—1.50 permissible range); chromium, 0.50 (0.30—0.75 permissible range); and carbon as below. All values expressed in per cent.

Desired Carbon	Permissible Range.	Desired Carbon.	Permissible Range.
0.15	0.10—0.20	0.35	0.30—0.40
0.20	0.15—0.25	0.40	0.35—0.45
0.25	0.20—0.30	0.45	0.40—0.50
0.30	0.25—0.35	0.50	0.45—0.55

Motor-car Nickel-Chromium Steels with Medium Nickel.

Manganese, 0.45 (0.30—0.60 permissible range); phosphorus, not over 0.04; sulphur, not over 0.04; nickel, 1.75 (1.50—2.00 permissible range); chromium, 1.00 (0.75—1.25 permissible range); and carbon as below. All values expressed in per cent.

Desired Carbon.	Permissible Range.	Desired Carbon.	Permissible Range.
0.15	0.10—0.20	0.35	0.30—0.40
0 20	0.15—0.25	0.40	0.35—0.45
0.25	0.20—0.30	0.45	0.40—0.50
0.30	0.25—0.35	0.50	0.45—0.55

Motor-car Nickel-Chromium Steels with High Nickel.

Manganese, 0.45 (0.30—0.60 permissible range); phosphorus, not over 0.04; sulphur, not over 0.04; nickel, 3.50 (3.25—3.75 permissible range); chromium, 1.50 (1.25—1.75 permissible range); and carbon as below. All values expressed in per cent.

Desired Carbon.	Permissible Range.	Desired Carbon.	Permissible Range.
0.15	0.10—0.20	0.35	0.30—0.40
0.20	0.15—0.25	0.40	0.35—0.45
0.25	0.20—0.30	0.45	0.40—0.50
0.30	0.25—0.35		

Motor-car Nickel-Chromium-Vanadium Steels with Low Nickel.

Manganese, 0.65 (0.50—0.80 permissible range); phosphorus, not over 0.04; sulphur, not over 0.04; nickel, 1.25 (1.00—1.50 permissible range); chromium, 0.50 (0.30—0.75 permissible range); vanadium, 0.18 (not under 0.12); and carbon as below. All values expressed in per cent.

Desired Carbon.	Permissible Range.	Desired Carbon.	Permissible Range.
0.15	0.10—0.20	0.35	0.30—0.40
0.20	0.15—0.25	0.40	0.35—0.45
0.25	0.20—0.30	0.45	0.40—0.50
0.30	0.25—0.35	0.50	0.45—0.55

Motor-car Nickel-Chromium Vanadium Steels with Medium Nickel.

Manganese, 0.45 (0.30—0.60 permissible range); phosphorus, not over 0.04; sulphur, not over 0.04; nickel, 1.75 (1.50—2.00 permissible range); chromium, 1.00 (0.75—1.25 permissible range); vanadium, 0.18 (not under 0.12); and carbon as below. All values expressed in per cent.

Desired Carbon.	Permissible Range.	Desired Carbon.	Permissible Range.
0.15	0.10—0.20	0.35	0.30—0.40
0.20	0.15—0.25	0.40	0.35—0.45
0.25	0.20—0.30	0.45	0.40—0.50
0.30	0.25—0.35	0.50	0.45—0.55

Motor-car Chromium Steels.

Manganese, 0.35 (0.20—0.45 permissible range); phosphorus, not over 0.03; sulphur, not over 0.03; and carbon and chromium as below. All values expressed in per cent.

Carbon		Chromium	
Desired.	Permissible Range.	Desired.	Permissible Range.
0.95	0.90—1.05	1.00	0.90—1.10
1.20	1.10—1.30	1.00	0.90—1.10
0.95	0.90—1.05	1.20	1.10—1.30
1.20	1.10—1.30	1.20..	1.10—1.30

Motor-car Chromium-Vanadium Steels.

Phosphorus, not over 0.04; sulphur, not over 0.04; chromium, 0.90 (0.70—1.10 permissible range); vanadium, 0.18 (not under 0.12); and carbon and manganese as below. All values expressed in per cent.

Carbon		Manganese	
Desired.	Permissible Range.	Desired.	Permissible Range.
0.15	0.10—0.20	0.65	0.50—0.80
0.20	0.15—0.25	0.65	0.50—0.80
0 25	0.20—0.30	0.65	0.50—0.80
0.30	0.25—0.35	0.65	0.50—0.80
0.35	0.30—0.40	0.65	0.50—0.80
0.40	0.35—0.45	0.65	0.50—0.80
0.45	0.40—0.50	0.65	0.50—0.80
0.50	0.45—0.55	0.65	0.50—0.80
0.95	0.90—1.05	0.35	0.20—0 45

Motor-car Silico-Manganese Steel and Valve Metals.

Carbon, desired		0.5 per cent
Carbon, permissible range	0.45—0.55	„
Manganese, desired		0.65 „
Manganese, permissible range	0.50—0.80	„
Phosphorus, not over		0.04 „
Sulphur, not over		0.04 „
Silicon, desired		1.75 „
Silicon, permissible range	1.50—2.00	„

Valve metal No. 1 shall be malleable and contain not less than 96 per cent. nickel. Valve metal No. 2 shall contain 8 to 35 per cent. nickel and not over 0.5 per cent. carbon, 1.50 per cent. manganese, 0.04 per cent. phosphorus, and 0.04 per cent. sulphur.

Iron and Steel Institute.

Programme of Annual Meeting.

As previously announced, the Annual Meeting of the Iron and Steel Institute will be held, by kind permission, at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, May 9 and 10, 1912, commencing each day at 10.30 a.m. From Mr. G. C. Lloyd (Secretary) we have received the following programme of proceedings:—

Thursday, May 9th.

General meeting at 10.30 a.m., when the Council will present their Report, and the Hon. Treasurer the statement of accounts, for 1911. The retiring-President (the Duke of Devonshire) will induct into the chair the President-elect (Mr. Arthur Cooper). The Bessemer Gold Medal for 1912 will be presented to Mr. J. H. Darby. The President will deliver his inaugural address, and a selection of Papers will be read and discussed (Nos. 11, 13, 3, 8, 14). The meeting will be adjourned for lunch at 1.30 p.m., and resumed at 2.30 p.m., when Papers Nos. 2, 1, 6, 7, 4 will be read and discussed as far as time permits.

Friday, May 10th.

General meeting of members at 10.30 a.m. The Andrew Carnegie Gold Medal (for 1911) will be presented to Dr. P. Goerens (Aachen) and the award of Research Scholarships for the current year will be announced. A selection of Papers will be read and discussed (Nos. 9, 10, 12, 5).

The Papers.

The following is the list of Papers that are expected to be submitted for reading and discussion:—

(1). "Notes on the Solubility of Cementite in Hardenite," by Dr. J. O. Arnold and L. Aitchison (Sheffield).

(2). "On the Chemical and Mechanical Relations of Iron, Vanadium and Carbon," by Dr. J. O. Arnold (Sheffield), and Professor A. A. Read (Cardiff).

(3). "Notes on a Bloom of Roman Iron from Corstopitum (Corbridge)," by Sir Hugh Bell, Bart. (Middlesbrough).

(4). "The Influence of Carbon on Corrosion," by C. Chappell (Sheffield).

(5). "The Manufacture and Treatment of Steel for Guns," by General L. Cubillo (Valladolid, Spain).

(6). "The Corrosion of Nickel, Chromium, and Nickel-Chromium Steels," by Dr. J. N. Friend, J. Lloyd Bentley and W. West (Darlington).

(7). "On the Mechanism of Corrosion," by Dr. J. N. Friend, W. West and J. Lloyd Bentley (Darlington).

(8). "Sinhalese Iron and Steel of Ancient Origin," by Sir Robert A. Hadfield, F.R.S. (Sheffield).

(9). "Modern Rolling-Mill Practice," by J. W. Hall (Birmingham).

(10). "The Influence of Heat on Hardened Tool Steels," by E. G. Herbert (Manchester).

(11). "Improvements in Electric Steel Furnaces and their Application in the Manufacture of Steel," by Dr. H. Nathusius (Friedenshütte, Upper Silesia).

(12). "A New Process for the Investigation of Fractured Surfaces of Steel," by F. Rogers (Sheffield).

(13). "The Welding Up of Blowholes and Cavities in Steel Ingots," by Dr. J. E. Stead, F.R.S. (Middlesbrough).

(14). "Note on some Remains of Early Iron Manufacture in Staffordshire," by Professor T. Turner (Birmingham).

Checkweighing in the Iron and Steel Industries.

The object of the Checkweighing in Various Industries Bill, recently introduced into Parliament, is to give effect to the recommendations of a series of Committees which were appointed, under the chairmanship of Sir Ernest Hatch, Bart., to ascertain the best means of enabling the workers who are paid by weight or measurement in certain industries to ascertain the correctness of the wages they receive. The Committees were four in all, and the industries into which they inquired were those mentioned in the Bill, namely: Iron and steel manufacture, chalk quarries and cement works, limestone quarries and lime works, and dock labour. Each Committee included representatives both of employers and employed in the industry forming the subject of its inquiry.

The Bill embodies the proposals of the four Committees and gives power to the Secretary of State to apply similar provisions, properly adapted, to other industries. The procedure for such application will be similar to that in making regulations under the Factory Act: Publication in draft, receipt and consideration of objections, and, if necessary, the holding of an inquiry.

The following abstracts are the regulations as to checking weights and testing estimated weights applicable to the production of manufacture of iron or steel:—

1. Where the iron or steel produced or manufactured is weighed by the employer on the employer's premises the workmen shall be entitled to appoint a checkweigher.

2. Where the iron or steel produced or manufactured is not so weighed, then—

(*a*) if the weight is calculated according to the weight of the materials used for the production or manufacture of the iron or steel and those materials are weighed on the employer's premises, the workmen shall be entitled to appoint a checkweigher to check the weighing;

(*b*) if the weight is calculated in accordance with the capacity of the moulds in which the iron or steel is cast, the employer shall, on being required in the prescribed manner so to do by the workmen, or a majority of them, cause the capacity of the moulds to be periodically tested at such intervals (not being less than fourteen days) and in such manner as, in default of agreement between the employer and the workmen, may be settled by arbitration, and in such case the workmen may appoint a checkweigher to attend at the periodical testing;

(*c*) if the weight is not so calculated, or if it is so calculated, but such periodical testing of the capacity of moulds is not reasonably practicable or would unreasonably interfere with the manner in which the process of manufacture is conducted, the weight shall be checked in such manner as, in default of agreement between the employer and the workmen, may be settled by arbitration, and if any dispute arises between the employer and the workmen as to whether such periodical testing of the capacity of moulds as aforesaid is not reasonably practicable or would unreasonably interefere with the manner in which the process of manufacture is conducted, the dispute shall be referred to arbitration.

3. Where in pursuance of the foregoing regulations the weight of ingots is periodically tested, whether by testing the capacity of moulds or otherwise, the wages to be paid to the workmen shall be based on the weight ascertained by the test applied for the purpose until the weight is again tested.

Making a 12-ft. Rope Pulley.

By Percy Jones.

Various methods of moulding large rope pulleys are in use in different foundries, but the writer will confine his attention to one which has been proved to give good results. The method mentioned is to form the mould in sections by means of cores, which, when all are placed in position, form the mould of the rope pulley. Fig. 1 shows a part elevation and section of a 12-ft. rope pulley, with six arms and eight grooves, the plan appearing in Fig. 2. Two core boxes are required, one to form the inside of the mould, the other to form the outside or grooves. The first-mentioned core box should be made the depth of the pulley, with the arm, section of the boss, and inside of the rim loose, so that the outside part can be drawn up, leaving the loose parts in position in the core. These loose parts are held in position by screws or pegs, which are easily withdrawn

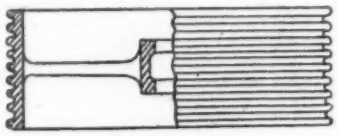


FIG. 1.

from the outside when the core is rammed up. The other core box, which is to form the outer part with the grooves of the pulley, is shown in Fig. 3.

Lifting plates (Fig. 4) are required for making the first-mentioned cores. These plates are made in open sand with wrought-iron staples cast in them. A number of straight irons, various sized sprigs, and a quantity of small ashes are also required in the making of these cores.

First a suitable joint board is procured and the core box placed on it, and a lifting plate is clay-

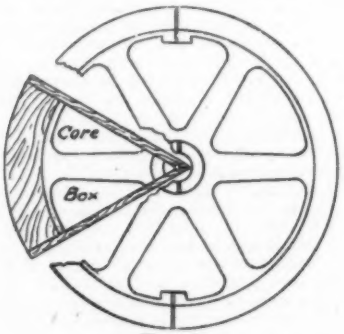


FIG. 2.

washed and inserted in the core box on the joint board. The section of the boss and the inner rim can then be screwed in position, and the arm slipped into its berth made by a taper joint. The core is rammed up, placing straight irons where necessary to strengthen the core, and a bed of ashes is laid under each arm, leading the vents up each side of the arm through the top of the core. Great care must be taken to vent down to the ashes at the end of the arms to get the air and gases away. When the core is rammed up, it is slaked round the side of the box with water, and well rapped, using mallets for the purpose. The screws which hold the loose parts in position are withdrawn, and the outer part of the core box is drawn up. Next the inner rim is withdrawn, then the section of the boss, and lastly the arm. Great care must be exercised to vent the face of the inner rim, especially under each arm, as the metal has to run through each arm to fill the rim, and if not thoroughly vented is sure to scab. This core is now ready to be blacked with liquid blacking, using a fine camel-hair brush for the purpose. This being in order, it is lifted by the staples of the lifting plate, which are attached to the chains of the crane, and hoisted on to the carriage of the stove. Six of these cores are required to form the inner part of the mould, and are placed in the stove to dry.

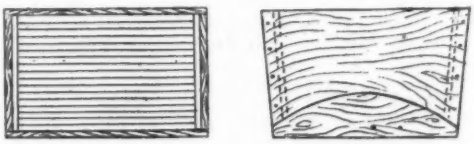


FIG. 3.

The outer core box, Fig. 3, will next be wanted. Prodded core irons (Fig. 7) are required for making these cores, and these are also made in open sand. Six of these cores are required to form the outer rim and grooves of the pulley. Sometimes when the pulley is required urgently, the coremaker will make these cores while the moulder makes the inner cores, which saves a good deal of time. Core plates (Fig. 6) are required to make the cores on, and are in use until the cores are dry. One of these core plates is placed on two small trestles, and the core box placed on it and rammed up, using ashes for vents. A chambered centre core is made, and also four splitting plates, which are covered with loam, then dried, tarred, and placed in the stove to dry. The next thing to do is to ram up the top box in the follow-

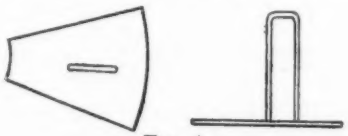


FIG. 4.

ing manner:—Two straight edges are placed in the foundry floor 14 ft. apart, for the purpose of making a very hard level bed. The object of this hard bed is to do away with making a flat board, which would add greatly to the cost of making the pulley. Dry parting sand is thrown over it, a small wooden wedge is driven in the centre of the bed, and a pair of trammels used for the purpose of marking out the boss, the inner and outer circles of the rim. Floor boards are placed on to the bed to stand on while marking out these circles; but, of course, must be removed before the top box is placed on. The bed should then appear as in Fig. 5. All is now ready for the top box, which is slaked with water and placed exactly over this bed by the crane. Two square runner pegs are placed, one at each side of the boss, and

four square riser pegs placed at equal distances round the rim. A bit of good sand is used for facing, and tucked under the bars by the fingers, then rammed up, vented and placed on legs, one at each corner of the box. It is then finished, blacked, and dried, by placing about six small fires under it.

The next job is to dig out in the foundry floor to receive all the cores a hole 16 ft. in diameter and the depth of the wheel, proceeding in the manner as for the top box, striking the circles out just the same. All is now ready for the inner cores to form the inner part of the pulley, these being placed according to the circles marked out. When these six cores are in position the joints on the face of the inner rim are made up with oil and blacking, afterwards being dried with a blow-lamp, or with hot plates. The next job is the cores for the outer rim or grooves of the pulley. These are lowered in position by the crane the same way, according to the circle marked out, and the joints made up as before.

When all this has been done an opening all the way round of 1 ft. behind the rim cores will be found.

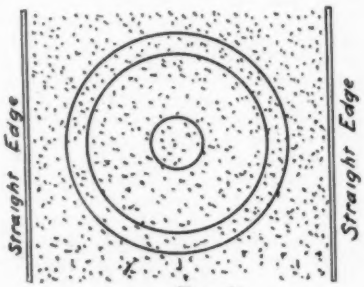


FIG. 5.

This opening is rammed up with green sand, to prevent the mould from bursting away during the process of casting, afterwards being strickled off level with the tops of the cores. The centre core and splitting plates are placed in position, and a small quantity of whiting placed round each vent of the cores on the top of the centre core and splitting plates, for the purpose of making an impression on the top box.

The top box may now be tried on, and it is generally the leading hand's job to get on the box and look down the runners into the boss of the pulley. It is then lowered and staked at each corner of the box, then hoisted and carried off to one side of the mould to see if all the cores, splitting

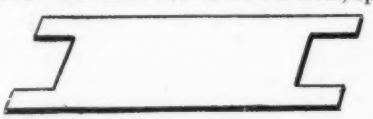


FIG. 6.

plates, etc., touch, and for the purpose of making holes through the top box to take the vent away from the inner cores, where the whiting has made the impression.

Everything being satisfactory, the box is finally placed on again, and all round the edge of the box is lightly rammed with sand, to prevent running out of the metal when the mould is full. The runner and riser pegs are inserted, and boxes placed on and made up. A piece of hay-band is placed in each vent hole in the top box leading to the main vents of the inner cores, leaving it projecting out of the top a little, and making them up lightly with sand. These hay-bands are set on fire when the metal enters the mould, as soon as the gases are made. The box is then weighted or clamped down and the pulley is ready to cast.

Three things in this work are essential to make a good, sound, clean casting, which will have no ugly joints on the arms, viz., clean metal, clean mould, and a clean runner box. Two runner stoppers (Fig. 8) may be used with advantage. Such a stopper is made of a cast-iron base with a wrought-iron staple cast in it. This base is covered with loam, then blackened and placed in the stove to dry. The stoppers are placed one over each runner just before the metal enters the runner box, and are left there until the runner box is full of metal, when they are lifted out by two men, one at each side of the mould, with a long piece of iron; the mould then commences to fill straight away. Thus the scum and impure metal floats on the surface and only the good, pure metal can pass into the mould. But great care must be taken to keep the runner box full of metal when once these stoppers are taken out. Plenty of men should be about when casting one of these large wheels, to prevent mishaps and be in readiness in case of emergency; there should be the foreman, two men at the ladle handle, one steering, one man skimming, two men lifting the

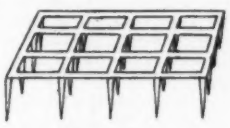


FIG. 7.

FIG. 8.

stoppers from the runner box (one man at each side), four men with shovels round the box side, and two men with hand shanks carrying metal for feeding the mould.

THE Provisional Committee of the Staffordshire Iron and Steel Institute which was formed to discuss the establishment of a technical library and joint office premises for the local learned societies have held several meetings to consider this matter, and made investigations as to the feasibility of the scheme. They report that the possibility of making arrangements to use the Birmingham Technical School Library has made possible a scheme which offers many advantages. This provides for the library portion of the original scheme, which portion was its most important feature, and reasons are given why the idea of having joint office accommodation and library is not recommended for the present. There is good reason to believe that, provided a sufficient number of learned societies combine to form what for the present is called the Midland Technical Union, and then approach the Committee of the Birmingham City Council, which is responsible for the management of the Technical School, either directly, or through the authorities of the Technical School, that Committee would favourably consider a scheme which would greatly facilitate the starting of a joint technical library on conditions not otherwise obtainable. It is proposed that the Union offer to provide the sum of, say, £70 a year towards the salary of a librarian, approved by the City Council, who shall attend in the afternoons to issue books to any students in the Technical School who have been furnished with readers' tickets by the technical school authorities, and to the members of the Union, also on production of their readers' tickets, the city authorities in return permitting the Union to store their library in the large room containing the books constituting the library of the Technical School. If societies having membership in the Midlands amongst them of 2,000 form the Union it would only be necessary to subscribe at the rate of 1s. 6d. per member, which would yield an income of £150 per annum.

Important Points in Foundry Practice.

Address before Newcastle Foundrymen.

A meeting of the members of the Newcastle and District Branch of the above Association was held on Saturday, March 30, for the purpose of hearing the Presidential address of Mr. R. Wallis, of Wallsend, the first President of the recently-formed Branch.

THE PRESIDENT, in opening, said that that meeting, being the first since the formation of the Branch, was an important one in the history of the British Foundrymen's Association. The membership had progressed satisfactorily, the present district membership being something like 40, with a prospect of several others joining before next session. The programme for the remainder of the present session consisted of a meeting in April, and another in May, when papers would be read on practical subjects of interest to foundrymen. Mr. Wallis then proceeded to deal briefly with some of the principal elements and conditions influencing the successful solution of the problem, which, he said, was before all foundrymen, namely, that of producing sound and satisfactory castings of such material as would be suitable, both in quality and character, for the conditions of the required service, and to produce those castings at a cost that would leave a sufficient margin of profit.

Dealing with the iron foundry, the nature and purpose of the desired casting and also the character of the local pig very materially affected the selection of pig and scrap in any particular foundry. It was therefore difficult to do more than state, in a general manner, the lines on which such selections should be made. The whole of the constituents of the pig and scrap, and their combined influence, had to be considered, especially the amount of combined and graphitic carbon in connection with the rate of cooling of the casting; also the capacity of the pig to combine with the desired proportion of scrap. Fracture had to be carefully considered, for although the grade of the iron was raised by remelting, the characteristics of the fractures of the various pig and scrap would be to a certain extent repeated in the casting. In important castings subject to changes of stress or temperature, something more than the strength of test bars had to be considered, especially if the casting was of an intricate nature. Ductility, ability to withstand vibration for prolonged periods, the avoidance of permanent distortion produced by changes of temperature, or the operation of machining, requirements in regard to wearing and rubbing surfaces, and ability to pass satisfactorily the hydraulic test, if necessary, were all important features to be carefully taken into account when selecting the mixture. To obtain a casting to fulfil those conditions required a mixture of pigs low in sulphur and phosphorus, with ample silicon to allow of a fair proportion of good scrap being used and prevent an excess of combined carbon. Speaking generally, the higher the price paid for the pig, provided it was correctly selected, the higher would be the properties of the casting.

Turning to coke, the President said that Mr. E. L. Rhead, in a Paper before the Lancashire Branch, had stated that coke for foundry purposes should be strong and hard, to resist the crushing effect of the burden in the cupola and the breaking up into small particles which were blown away by the blast and became mixed with the slag. It should be dense, have good cell structure, be free as possible from ash, contain little sulphur, the presence of which could be detected by a smell resembling that of rotten eggs. Uniformity was also necessary for good results, as soft portions burned more readily than the harder portions, and the mass broke up before the combustion was complete, the necessary temperature for rapid melting was not maintained, and strong blasts could not be used. In regard to blast, no definite rule could be given for the blast pressure in a cupola, the conditions in any two foundries, even with the same diameter and height of cupola, not being the same. Speaking generally, he thought the best results would be obtained from a blast well distributed around the circumference with two rows of tuyeres and as low a pressure as the height and character of the burden would permit. Coming to the question of blowers or fans, he remarked that until recently blowers had been the more satisfactory in running and upkeep, but the latest design of high-speed fan, especially when direct coupled to an electric motor, gave excellent results, being more flexible in manipulation. As to cupola design, the President continued, the general opinion was that, with a view to coke economy, the distance from the tuyeres to the charging door should be moderate and not too high, about 12 ft. being accepted as the best height. Opinions differed as to the shape of the lining, and also as to the form of the tuyeres. Judging from results given by the users of the different forms of linings and tuyeres, these had little, if any, effect on coke consumption.

The points to consider in cupola design were: to admit the air in such a manner as to complete the combustion of the fuel in the melting zone, and avoid the formation of carbon monoxide above it with its great waste of heat, which caused flaming at the charging door and top. The wearing away of the lining at the melting zone, with the necessity for daily repairs, and its influence on the metal, tending towards defective castings, might be influenced by some change in design. The heating of the blast by the waste heat now lost at the top of the cupola had been suggested, and it would be interesting to hear the result of experiments in this direction. Mr. Mason, of Leicester, in a recent Paper, had said he obtained the best results by keeping the coke as much as possible in the middle of the cupola, placing the iron around the wall and endeavouring to form a pillar of coke up the centre of the cupola. Since Mr. Mason's coke consumption was as low as 1¾ cwt. per ton, including all fuel, that method would appear to deserve some consideration.

The addition of ferro-silicon, ferro-aluminium, ferro-titanium, or any other alloy to the metal in the ladle for the removal of oxides and nitrides was a practice for which many claims were made regarding the reduction of wasters and the improved quality of the castings, but, generally speaking, it was much safer and more reliable to deal with the materials before they were put into the cupola, rather than to try and improve them after they were melted.

In the matter of core stoves, the President said, if fired by producer gas instead of the ordinary open fire the result would be a considerable economy in fuel. A thick layer of sand on the roof would also give good results in the reduction of radiated heat, as well as doors formed of asbestos cardboard, which were lighter to operate.

In conclusion, he emphasised the necessity for training the power of observation. In order to discriminate between the probable and the actual facts which had contributed to the making of a defective casting, it was necessary to closely observe every step of the process, from the selection of the metal to the finished casting.

Discussion.

At the conclusion of the address, a considerable amount of discussion took place amongst the members on various points raised.

Mr. James Smith said he had found gas handy, as it could be put on day or night, but it was very deceiving. He might have a stove going all night and in the morning, although the material looked dry, on examination the drying would perhaps prove to be only skin deep.

Mr. Gallon asked whether the accumulation of slag caused erosion of the cupola lining, or whether it might not be the high blast.

Mr. Henderson said he thought it would be agreed that the blast had a good deal to do with the eating away, but he had observed that it did not eat away above the tuyere so much as at the other side, where it was not expected to get the blast heat.

Mr. Smith said he had tried melting iron by building the coke as near the centre of the furnace as possible, but he would never attempt it again. His idea for charging a furnace was to have his coke spread about the furnace, have the metal as closely packed as possible, one charge on top of the other, and if they had a good furnace and a good blast he did not think it would take any harm.

Mr. Gallon said he was rather sceptical regarding putting the coke in the centre. With regard to the slag and the burning of the lining, he was of the opinion that the slag had nothing to do with the burning of the lining, but that the blast did it. In their cupola they had arranged so that the blast main came right under the bottom of the cupola, and there was one upright tuyere at one side of the cupola and another at the opposite side. He had told the cupola man to put the slide in halfway, thus exactly balancing the blast, so that the lining was burned out regularly all round, proving to himself, anyhow, that it was the blast and not the slag which caused the burning away of the lining.

Mr. Atkinson said he had seen a stove built in cast-iron with the flues at each side of the stove right up to the top, which was a great advantage. Then in regard to stoves for drying by gas, he had seen some steel works use it frequently, but, in connection with ordinary foundry practice, a closed fire, bridged over with a flue leading down the centre of the floor was a great advantage in saving coke.

The President, in his reply, said that from Mr. Smith's tone he could gather pretty well the type of producer of which he had had experience, and he (the President) was not surprised at the result. That producer would be making gas from anthracite coal, and there would be several factors, such as tar, which would tend to produce the results mentioned by Mr. Smith. With reference to erosion, it was the slag which eroded the lining, but the blast helped it. Blast of itself would not burn out the lining unless there was attained a very high temperature right against the walls—a temperature so high that the bricks would be melted. With regard to the detection of sulphur, he had heard it said that if on breaking a piece of coke very fine, beautiful colours were disclosed, the presence of sulphur was thereby indicated. As a matter of fact, such was not the case; that appearance was an indication of tar. If a piece of coke were heated to the burning point, bright red hot, and were then quenched suddenly in cold water, the presence of sulphur to any extent would be detected by the characteristic smell of sulphuretted hydrogen (the before-mentioned smell of rotten eggs), or sulphur oxide might be produced. In regard to tuyeres, the advantage of a second row was that this tended to reduce the formation of carbon monoxide on the upper portion of the melting zone.

The proceedings terminated with a vote of thanks to the Chairman.

Chromium in Non-Ferrous Alloys.

Chromium has only been generally known as a metal for about 15 years, and only quite recently has it come before the public as a constituent of the non-ferrous alloys, though there are many undetermined possibilities before it. Chromium, which was discovered by Vanquelin, is a metallic element somewhat resembling iron, being hard, grey in colour and with a high melting point. Ostwald states the melting point of pure chromium to be about 2,000 deg. C. The specific gravity of the metal is 6.7 (water at 60 deg. F. = 1). It has the important characteristic of not scaling, as do copper and iron, when heated to red-heat in air, for which reason it is employed in resistance alloys for electric heating devices. Chromium has found considerable employment as a constituent of tool steel, in which it is employed as a hardener; and also it has been plated on to other metals in the same manner as nickel, which metal it much resembles in that form. But in the non-ferrous world it has not been given much scope. Where, however, it has been employed, the results have suggested important developments in the future for its use in special work.

Perhaps one of the best known of the non-ferrous alloys in which chromium is a constituent is the American alloy "Chromax," which is said to have the following composition:—Cu. 66.66 per cent.; Zn., 12.13 per cent.; Ni., 15.15 per cent.; Cr., 3.03 per cent.; Al., 3.03 per cent. This alloy has considerable strength, giving tensile test results up to 35 tons per sq. in., with over 3 per cent. elongation. An alloy of almost identical composition has recently been brought out in France. This is made in the following manner:—Chromium 11 lbs. and aluminium 11 lbs. are melted together at a high temperature for one hour; 242 lbs. of copper are added, and the whole kept in a molten condition for half an hour; 55 lbs. of nickel are added, and the whole again kept molten for another half-hour; after this 44 lbs. of zinc are introduced, and the metal is poured into ingots. Some variation is allowed in the amounts of chromium and of copper, but the order in which the metals are introduced must not be varied. The colour of this chrome-nickel-bronze alloy is white, and the fracture fine and dense. Its high tensile strength should recommend it for many purposes which at present employ other alloys such as manganese bronze.

At the moment the cost of chromium militates against the use of the pure metal, as it costs about 3s. 6d. per lb. It is prepared by the reducing action of aluminium on its oxide (Cr_2O_3), and also by electrolysis of its salt solution. For use with the ferrous alloys it is much cheaper, as it is then employed in the form of a chromium-iron alloy made by direct reduction with carbon. The future should, however, witness considerable advances in the production of chromium for non-ferrous uses, when its employment may fairly be expected to greatly increase.

Mechanical Core Making.

By H. S. Green.

Mr. H. S. Green, of London, lectured on "Mechanical Core Making," on March 19, before members of the Sheffield Branch of the British Foundrymen's Association. The lecture was largely attended, and Mr. Percy Longmuir, B.Met., President, occupied the chair.

The LECTURER said for the purposes of this Paper they would assume that the cores referred to were those that, green or dry, were made apart from and set into the moulds after they had been completed. Since the advent and development of the moulding machine, many parts of castings formerly made by dry-sand cores, were now made by contrivances on the moulding machines. But he should confine himself to those cores that were made entirely by separate machines in core boxes of one kind or another, and that were either placed in the mould green or dried, as was best for the work under consideration.

The earliest attempt to make a core machine that he had been able to trace was in 1893, or only 19 years ago, when a Mr. F. A. Williams, of Newport, patented an "improved appliance for making loam cores." This consisted of a rotary bar and board, and was intended for making the loam cores for pipes. Three years later Messrs. Singers patented a machine for making their sewing-machine arm cores which had since been developed for other work. The next in importance was the rotary machine in 1901, and from thence onwards they had various machines at irregular intervals.

Inventors had striven, with more or less success, to produce machines that would not only increase the rate of production, but would also produce more accurate cores. Experiments had proved that not only were the cores more accurate and the rate of production increased, but the cores were also superior in that they vented better owing to the uniformity in ramming, and there was less likelihood of swelling taking place.

The unsatisfactory nature of round cores made in halves and packed together was well known. The accuracy of the core depended on the accuracy of the core box, which had a tendency to wear oval. Even when the core was accurate there was a fin left where the two halves had been joined together. A machine-made core was perfectly round, without any seam or fin, and left a straight hole of great accuracy, so that only the slightest margin needed to be left for machining.

In regard to this question of accuracy, he pointed out that the mixture employed had an effect upon the exactness of the cores, as some mixtures were more liable to swell during the drying process than others. He heard recently of some fairly large cores that were found to have swollen $\frac{3}{8}$ in. during the drying process, making a fit impossible.

Turning next to the various machines, the Lecturer referred to the "rotary" machine first, not because it was first in the field, but because he thought it was found in more core shops than any other machine or device. The Wadsworth machine No. 1 was designed for making parallel cores from $\frac{3}{4}$ in. to 3 in. diameter. Because the machine was simple it must not be imagined that experience was not necessary. Most firms had difficulties at the start in securing the proper mixture of sand, with cores bending when cast horizontally, with troubles caused by the dies and conveyors not being properly cleaned, and in other ways. Patience should be exercised and trouble taken to carefully investigate the faults, when a remedy would undoubtedly be found. The "rotary" machine made a continuous core, and required a special mixture of sand containing flour and oil, and made up of approximately 100 parts of silica sand, twelve parts flour, and one part oil. He believed this mixture could be cheapened by experimenting with the sand they had available. If regular quantities of cores of a given length and diameter were required, he was of opinion that it was better to use the vertical plunger machine, as the cores were then made to the exact length required.

The lecturer illustrated his remarks with numerous slides of different machines. He showed a machine designed to make cores from $\frac{3}{4}$ in. to 7 in. diameter, to be used either by power or hand. He showed it with a 36-in. hand-wheel for the purpose of making hand cores, and built to go on a wooden bench. Next he showed the machine built for power only, with two speeds, one being used for making cores from $\frac{3}{4}$ in. to $2\frac{1}{2}$ in., and the other, the slow speed, from $2\frac{1}{2}$ in. to 7 in. He had heard that recently the machine had been developed so as to make cores up to 15 in. diameter.

Everything, of course, was not possible on a rotary screw-feed machine, and he expected they were acquainted with the Swedish machine that made cores by a plunger ramming the sand into the core tubes. The Wadsworth people received an order about 12 months ago for some core machines to be arranged for producing a maximum output with a minimum of labour. To accomplish this, two machines were mounted on one stand at the right and two small machines on a stand at the left. On the same stand on which the small machines were mounted were placed a pair of cutting-off wheels. The machines were operated as follows:—The large machines on the right were capable of making cores from $\frac{3}{4}$ in. to 7 in. diameter; in fact, these machines could be fitted with dies making up to 11 in. in diameter when mounted. The machine for making the large cores was operated by one man, and he had as much as he could do to supply the sand for both hoppers, which was done from one sand box above the machine. The sand box was mounted on a track so that it slid backwards and forwards, allowing the operator to place sand first in one hopper and then in the other.

Ordinarily in making cores on machines of this type, the cores were run out the full length of the plate, baked and subsequently cut to length. But in this core a large number of short cylindrical cores were required, and it was decided to cut them previous to baking. To accomplish this the machines were provided with quick-action clutch pulleys, controlled by foot levers beneath the machine. By this means the core could be run out to any desired length within $\frac{1}{4}$ of an inch, it was then cut off at the front end of the die, by means of a thin knife; another length of core was then run out and this likewise was cut off. The cores were left in contact with each other on the plate until after they were baked, when they were found to separate quite easily. Where cores were cut to length in this way, if the lengths were short an operator could only control one machine at a time, but with standard length cores he had no difficulty in controlling both machines, though the large volume of sand necessary in cores above 3 in. in diameter kept a man hard at work feeding out and cutting off the cores. Another boy was necessary to take the plates to the oven and bring sand to the machine. For making

cores from ½ to 3 in. the small machines were used. The sand required for these small cores was less than in the other case, and the boy who attended the machine could easily change the core plates and place his finished cores in the rack ready for them to be taken to the oven. For cutting the small cores to short lengths the cutting-off machine was found more economical than the cutting off of the cores at the end of the die with a thin knife. Hence the cores were run out the full length of the plate, baked and then cut off. For the operating of the small machine one boy was required to make the small cores and another to cut them off, and to assist the first by bringing sand to the machine or performing any other work which might be necessary, such as removing core trays to the core oven, etc.

The vertical plunger core-making machine was next considered, the advantages claimed being that the cores were made to the exact length required, they were made in the ordinary core sand in use in the foundry, they could be wired and vented as necessary, and several could be made at the same time. With machines of the plunger type it was better not to make the length of the core to exceed five to six times its diameter, as otherwise trouble in getting them too hard was almost sure to result.

Turning to cores required for such fittings as bends, tees, cross-pieces, etc., or valves, bib-cocks, and many other varieties, Mr. Green first dealt with the machine patented in 1899 in Germany by Albert Knuttel, of Remscheid, for making the cores of small fittings. Although considerable alterations and improvements had been made in the machines now employed, the construction of the core boxes or plates remained practically the same as it was when it was first thought out. Knuttel pointed out that the class of cores covered by his patent were usually made by hand in metal core boxes, the two halves of the boxes being held together by cramping screws. The making of cores in this way was slow compared with the facility with which the moulds for corresponding articles could be produced and the amount of repair work on the core boxes to keep them accurate was enormous. With Knuttle's machine these difficulties were overcome, as not only were the core boxes produced with rapidity, but the item for repairs to core boxes was conspicuous by its absence. The machine would work with practically any core sand mixture, but care should be taken not to use one of too sticky a nature, as it involved a great waste of time in cleaning the plates. The Lecturer then described the machine in detail, showing numerous photographs. He also illustrated the use of a wooden intermediate core box.

Recently the jar-ramming core-making machine had been making great headway in America, and this was shown, as also a machine for making the cores for Metropolitan Water Board socket pipes. These latter were not plain, and it was necessary to part the core boxes sideways before the cores could be lifted out. The output was not quite as large as with plain socket cores, but quite satisfactory, and much larger than by hand core making, with the added advantage of uniform ramming, no soft and hard spots, accurate cores and no repairs. Cores for axle boxes required careful treatment to produce them with accuracy. They were best made on a hand-ramming turnover machine, which was very simple to use, and would produce cores of great accuracy. The making of the machine and core boxes to secure this accuracy in working was a somewhat complicated and expensive matter.

The Lecturer contended that although the machines at present on the market showed considerable advance on hand core-making, there was a very wide field for development yet, and practically only the fringe of the subject had been tackled. Undoubtedly during the next few years they would see considerable advances in appliances for core making.

The workman would get the best results who paid special attention to the mixing of the core sands and the drying of the cores. Many wasters were put down to the moulder or the core-maker which were the result of careless drying.

Discussion.

The PRESIDENT remarked that he had no idea that the mechanical core-maker had been developed to the extent indicated. With the earlier machines they were all more or less familiar, and they could all realise that the production of a plain cylindrical core was a comparatively easy matter. But the intricate cores which had been shown to them were not so easy. Most ingenious methods had been adopted by the various inventors to overcome the many difficulties. He was particularly interested in the sewing machine arm core; he had many years ago some slight connection with the introduction of that machine. He knew several of the people who worked on it, and he knew also something of the difficulties with which they had had to contend.

MR. THOMAS H. FIRTH, Vice-President, said he had not considered much the question of mechanical core-making, because in his business they had unfortunately very little repetition work; but there was no question about it, the machine must be of the greatest advantage to firms who had to deal with repetition work.

MR. HAWKINS alluded to the rapidity with which pipe cores were to-day turned out at the Staveley Works, near Sheffield. But he would like to know if a machine could be made a commercial success when only small quantities were required. His view was that machines were of the greatest value to firms who specialised, but in Sheffield there was very little repetition work.

MR. W. H. HATFIELD remarked that although mechanical core-making had been in vogue 19 years there had been nothing like a general adoption of the method. He was recently going through a large works and he asked the manager to let him look at his core machines. He showed him a boy and remarking there was nothing to beat that, told him that he made 400 in the hour. He was making by hand, so that the machines were up against something there. (Laughter.) Of course, a machine could do the work more accurately, but he saw very great difficulties unless the repetition work was fairly extensive.

MR. HYDE said they must realise that these machines were only useful to firms who specialised. There was a great tendency in that direction in these days, and the demand for the machines was thought likely to increase. But while it was surprising the good results that could be obtained from a machine, it was also surprising the humbug they would have if they did not see that care was taken with the machine.

MR. GREEN, in his reply to the discussion, remarked in regard to binders that he would advise those who required information on this subject to read Mr. Lane's article which dealt with experiments carried out in America for 4½ or 5 years. As to venting cocks, where it was essential to vent it could be done by wax wire. He admitted that it was useless to put down a machine for irregular cores unless they were going to deal in numbers. The cost of the machine was fairly heavy, and it was only suited for repetition work. Mechanical core-making was still in its infancy. It had not developed to the same extent as moulding machines, but some progress had been made, and he ventured to prophesy that in the next five years the development would be very rapid.

Moulding a Conical Flanged Pipe.

By Francis W. Shaw.

The illustrations (Figs. 2 and 4) show two methods of making the conical flanged pipes shown in Fig. 1. Previous to the adoption of the methods shown, these had been made from a pattern in halves longitudinally, the inside being taken out with a dry-sand core. This was obviously an expensive method

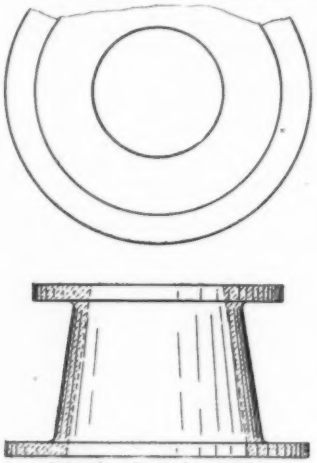


FIG. 1.—THE CASTING.

compared with either of those shown. The cost of making and drying a dry-sand core is quite an item in the final cost of such work. The quality of the castings as regards appearance, owing to the rough interior and the longitudinal joint along the casting, was not as good as with the all-green-sand method.

After this, the method as shown at Fig. 2 was adopted with a considerable increase in output, not to speak of enhanced appearance of the work.

The procedure was as follows: The bottom part was rammed up and strickled off level, and the lifter

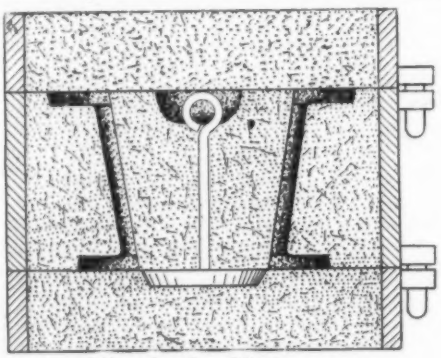


FIG. 2.—OLD METHOD.

plate bedded in. The pattern and middle part were placed in position and the latter and core rammed up. Owing to the absence of space round the edge of the large flange this was rather difficult, and required considerable care to avoid soft ramming, particularly at the corners immediately beneath the flange. The top part was finally placed in position, rammed up, the runner cut through to the second joint with a brass tube and finished off. (Gates and runners are not shown in the drawing.) The top part, main part of pattern, middle part, and flange of pattern were then removed in the stated order. The gate was cut into the lower flange and trimmed

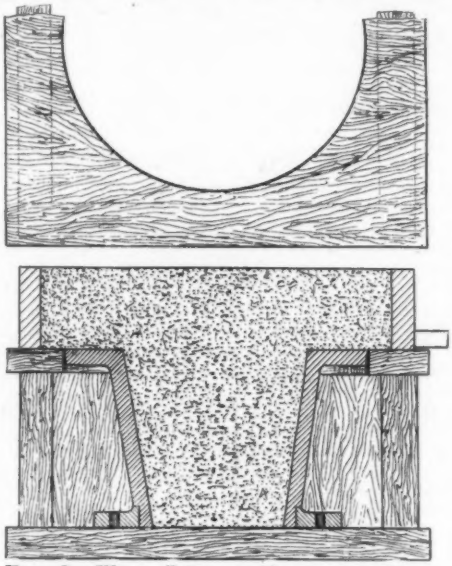


FIG. 3.—WOOD JOINTING FRAME FOR NEW METHOD.

up, after which the mould was assembled ready for pouring. The finished mould had the appearance as shown in Fig. 2.

It was thought that this method was hardly capable of undergoing improvement, and the suggestion of a new method, as shown by Figs. 3 and 4, met with

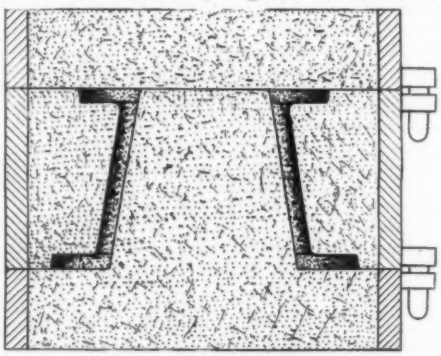


FIG. 4.—NEW METHOD.

little enthusiasm. However, it was finally decided to give it a trial, with the result that the output was increased by very nearly 50 per cent. How this was done is not very obvious, but a careful examination of the operations involved will disclose that quite a number of operations are saved—jointing and bedding in the core lifter, for instance. It was found much easier too, to lift off the middle part from the pattern than it had been to lift the core out of the pattern.

The procedure for the new method was as follows: The bottom part and core were rammed up in one piece, the pattern being located by a special wood jointing frame shown in plan and elevation at Fig. 3. After ramming, the whole was rolled over and the jointing frame removed, the middle and top parts being then rammed up in the usual way. To remove the pattern the top part was removed; the pattern was well rapped by the holes shown, and the loose flange, the middle part, and pattern removed in the stated order. After preparation of gates, etc., the mould was assembled, presenting the appearance shown in Fig. 4.

The Hering "Pinch Effect" Furnace.

In our last issue we published in abstract a Paper by Mr. E. Kilburn Scott on the Hering "pinch effect" furnace, recently presented before the Faraday Society. Since many of our readers may not be familiar with the "pinch" phenomenon upon which the operation of the furnace is based, we present herewith some further particulars.

In 1907 and 1909 Mr. Carl Hering described in Papers presented before the American Electrochemical Society a peculiar "pinch effect" which he had observed in electric furnaces. It appears that there is a limit to the current which can be passed through a horizontal open channel containing a liquid. When the current reaches a certain amount, depending on the cross-section and shape of the column and

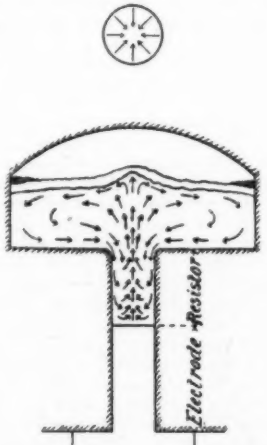


FIG. 1.—CIRCULATION OF METAL THROUGH "PINCH EFFECT."

on the specific gravity of the liquid, the column is suddenly contracted by electro-magnetic forces until it breaks the circuit. This produces rapid interruptions of the current which prevent a further increase of current and are fatal to the operation of the furnace.

Mr. Hering devised a practical application of this "pinch effect" and his electric furnace, in which it is made to serve the useful purpose of rapid circulation, is the one referred to in our last issue.

If a column of a liquid conductor is confined in a vertical cylindrical hole in the bottom of the hearth, opening into the body of the liquid and closed at the bottom by means of the electrode, and if a current be then passed lengthwise through it, the effect of the pinch phenomenon will be to contract this column toward its central axis; the liquid will therefore tend to move radially from the circumference to the centre, as shown in the small circle at the top of Fig. 1. These forces, in turn, by hydraulic action, then produce an axial force which will impel the liquid upward and out of the column, while at the same time the suction will draw in fresh liquid around the circumference, producing a circulation about as shown by the arrows in Fig. 1. This peculiar phenomenon acts like a valveless pump, forcing the liquid upward and producing a small fountain.

These liquid columns or resistors, of which there are two, one for each electrode, are so proportioned that the whole heat for the furnace is generated in them, and the diameter and current are so proportioned that the pinching force is sufficient to produce the desired circulation. Each particle of the liquid in turn enters the resistor, where it is immediately highly heated and ejected, being in the resistor only about a second. The freshly heated metal is forced to the top where, in the case of steel refining, it comes into intimate contact with the blanket of slag, where the chemical action which constitutes the refining takes place. The cooler material at the bottom flows into the resistor and is in turn heated and ejected. For three-phase current there are three resistors and electrodes.

Among the advantages claimed are:—Quick action, which means a large output per day and less stand-by

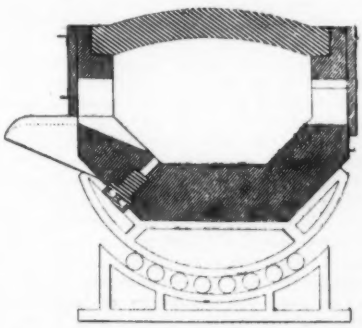


FIG. 2.—SECTIONAL ELEVATION OF TILTING ELECTRIC FURNACE WITH CARL HERING RESISTORS.

losses per ton; a very large effective surface of contact with the slag, as this surface is continually being renewed, hence rapid refining action; rapid purification from suspended matter; heating from the bottom, which is the more rational method; practically perfect homogeneity, on account of the rapid and systematic circulation; possibility of making the hearth deep and narrow instead of shallow and broad, hence reducing the rather large losses through the walls; reduction of the temperature to the lowest necessary for the chemical reaction; the possibility of using metal electrodes, which are much more economical in losses of power than those of carbon or graphite; no consumption of electrodes; no contamination of the material with that of the electrode, as the latter is made of the same material; no continual adjustment of the electrodes as in arc furnaces; ease and nicety of regulation by merely varying the voltage of the transformer.

Fig. 2 shows how these resistors or squirting tubes and their electrodes may be applied to the usual type of tilting furnace.

The "Stock" Converter Process.

At a joint meeting of the Sheffield Society of Engineers and Metallurgists and the Sheffield Branch of the British Foundrymen's Association, held at the Firth College, Sheffield, on Monday, April 22, an interesting lecture on "The Stock Converter Process," was delivered by Mr. W. Stock, of Darlington. Mr. Percy Longmuir, B.Met., President of the Foundrymen's Association, presided. The "Stock" oil fuel converter was illustrated and described at length in our issue of October last.

The lecturer said the process was essentially different from any other Bessemer system. The features were, melting with oil in the converter itself, and using hot air obtained from the waste heat during the time that oil was being burned in the converter. The advantages of using oil fuel in the converter were that little, if any, impurities were picked up during melting, and the charge could be made properly fluid by simply continuing the operation. Also, when the converter was turned up to blow, all the brickwork was at a high temperature, and did not absorb much of the heat generated during the blow.

The result of using hot air in the way he had described was rather more complex. The temperature started at the beginning of the first charge at 120 deg. C. and rose during the day to as much as 400 deg. C. This helped matters by reducing the amount of fuel required for melting, having a less chilling effect on the bath during blowing, and also enabling the mechanical functions of the blow to be carried out with less volume of air, and consequently less weight of oxygen.

To carry out successfully the surface blowing of a bath of metal it seemed to be necessary to apply a certain amount of power from the blast for the purpose of stirring the metal, and in blowing a 3-ton converter with cold air one would require a blower with a capacity of 6,000 cub. ft. of free air per minute; and, with the composition of metal he was considering the blow would take about 20 minutes. Now with air heated up to between 200 and 400 deg. C. the blower required had only a capacity of 3,000 cub. ft. of free air per minute, but owing to the temperature the air was heated up to after it left the blower they were able to obtain the required mechanical effect on the bath without passing such a large weight of air through the converter, although the time required for the blow was about the same, namely 20 minutes. He though it was quite reasonable to suppose that the bath during surface blowing took what oxygen it required from the blast, and even with the less weight per minute it received with hot air there was still an excess which escaped during the first period and combined with the gases given off during the second period—after the flame appeared. In his opinion the value of using hot air during the blow lay in the fact that when the flame dropped the operator had more time to turn down the vessel and shut off the air and so avoid over-oxidation. This seemed to be the explanation of the fact that, given an intelligent operator, steel in the ladle was almost uniformly thoroughly deoxidised.

The lecturer illustrated his Paper with a number of slides, showing the construction of the converter, the charging, the melting, blowing and teeming positions. The bottom of the converter stand is a turntable, running on balls and fitted with a rack which is operated by a 10-h.p. reversible motor. The blast pipe passes through the bottom of the turntable and is fitted with a stuffing box to allow the converter to turn on its vertical axis; it then passes up the housing and into another stuffing box to allow the converter to be turned on its horizontal axis by a 10-h.p. totally-enclosed motor carried on the other housing and operating through a worm gear, and so into the blast box, which may be split or one single box. The blast box has holes fitted on the outside opposite to the tuyeres to admit the oil pipes, which are simply steel tubes about 1-16 in. diameter, connected with the oil tank by flexible pipes and inserted into the tuyeres during the heating up of the converter and melting the charge. The economiser is a brick chamber fitted with cast-iron pipes and used for heating up the blast with the waste products of combustion of the oil only.

Explaining the operation of the converter, the lecturer said a small wood fire was lighted at the back of the vessel, then its position was changed, and the oil and blast turned on for 30 to 40 minutes, at the end of which time the lining was white hot and the vessel ready to receive the charge. Three men could put in three tons in about eight minutes. The oil and air were then turned on. The oil was lighted by the red-hot walls of the converter, and, after setting the blast pressure to ¾ lb. and regulating the oil so as to get a white flame at the mouth, nothing further needed to be done except regulate the oil valve from time to time during the next two hours or so, by which time the charge would be ready for blowing. After putting a rake through to feel that everything was melted, the vessel was turned into another position, the oil tubes removed, and the level of the metal set by looking through the tuyeres. The holes which held the oil pipes were then stopped up with dummy pieces, and the full blast pressure of 3½ to 4 lbs. put on, when the process was completed by an ordinary surface below, the waste gases being led through a hood and chimney over the front of the economiser. Near the end of the blow, broken glass was added to thin the slag—about 14 lbs. to the ton charged.

A 4B Roots' blower was used to supply the blast, driven by a 110-h.p. D.C. motor, 220 volts, 600 r.p.m., and the oil was introduced into the converter under pressure of 40 to 50 lbs. per square inch, obtained by compressed air introduced into the top of the oil tank and allowed to blow off very slightly through an escape valve set at the required pressure, this being the simplest means of keeping the oil at a constant pressure. The vessel was lined with shaped silica bricks, and, in the furnace which was illustrated was 9½ in. thick, except at the tuyeres and below, where it was 14 in. at the thickest part. This lining lasted from 25 to 30 heats without repair of any kind; then the converter shell was removed, a new one placed in the stand, and the necessary repairs carried out on the old one by renewing the lining where it was worn. It would then run perhaps 20 more heats before requiring further repairs, but after that the whole lining had to be renewed.

In operating the furnace the points to be observed were :—

(1) Not to charge the converter till it was thoroughly hot, which could be generally ascertained from the blast temperature, which should be 120 deg. C.

(2) To obtain a clean melt of the charge before blowing.

(3) To have the level of the melted metal well up to the tuyeres before starting to blow; the angle at which the converter stood could vary from nearly perpendicular to 25 degrees out of the perpendicular, but it was essential for the metal to be almost up to the bottom of the tuyeres.

(4) The composition of the charge. This in practice seemed to work best with an average of 1.8 to 2.2 per cent. silicon, and 0.8 to 1.2 per cent. manganese, with sulphur and phosphorus content as required, since there was practically no change in the percentage of these elements in the finished steel as compared with the charge.

The maximum amount of scrap which could conveniently be charged was 30 per cent., as more than that unduly increased the amount of fuel used.

Proceeding, the lecturer said the converter shown had now been running for about two years, and the results of this plant had shown that, including lighting up every day, the fuel consumption was about 30 gallons per ton of steel in the ladle. That figure was arrived at by measuring all the oil used, and weighing every ladle of steel which was taken from the converter. The power consumption had also been carefully measured, and worked out at 30 units per ton of steel in the ladle. The loss on the charge during the whole operation was about 14 per cent. over an extended period. The only other item which was of great importance was the cost of the lining. This was about 8s. per ton of steel in the ladle, but, of course, the wear on the lining would be governed by the quality of steel produced. A 3-ton furnace was worked by three men—one blower and two helpers. These men were able to weigh in their own metal, keep the furnace in order, and do all the work necessary to turn out about 50 tons a week, working single shift. Taking the question of cost altogether, steel could be produced in England by this process for about 25s. per ton above the price of pig-iron and scrap, provided that oil could be obtained at 2½d. per gallon and electric power at 1d. per unit, but without standing charges.

The lecturer went on to speak of the work which had been done by the process. For the most part it had been used in the manufacture of small steel castings. The steel was in nearly every case blown down to about 0.10 per cent. C. and then recarburised by addition of spiegel, pig-iron, etc. Up to 0.40 per cent. C. could be got with the addition of red-hot pig-iron, but for over that it was better to put in a proportion of melted pig-iron. As a general rule, however, the castings were made with a carbon content of 0.2 per cent., and the metal was so fluid that pieces 3-16 in. thick and 12 in. long could be easily run. He illustrated on the screen some of the castings, which he said gave an average annealed test of 30 tons tensile and 30 per cent. elongation on 3 in. This was a result which was obtained by other systems, but the regularity of the results obtained by the "Stock" converter had been remarkable. In the case of a tumbler mentioned, which had sides about 1-16 in. thick, the steel was poured from a 3-ton ladle through an inch stopper into a hand ladle, and six tumblers were cast without a failure.

So far as the production of very light castings was concerned, however, he should not recommend a large converter at all, unless the foundry wished to make intermediate pieces as well, since the time occupied in pouring the whole of the three tons into castings not more than 25 lbs. weight would be so long that the steel in the ladle would set. To meet this demand, they had designed a "baby" converter on exactly the same system as a 3-ton furnace, but hand-turned and tilted, with a capacity of 10 cwts.; and with this converter, operated in exactly the same way as the one he had illustrated, it was common practice to cast 10 cwts. of steel every two hours into pieces of from 4 ozs. to 10 lbs., without any undue amount of scrap in the ladles. The steel in this case was poured straight from the converter into hand ladles of about 60 lbs. each, and with six of these ladles the whole of the charge could be run without difficulty. He showed slides of sections taken from steel castings made by this process, and compared with steel made by the acid open-hearth. These had been prepared to give some idea of the slag inclusion one might expect to find, and which seemed rather remarkable for its absence. He thought the difference was due to the very fluid condition of the steel, which permitted of the rapid separation of slag mixed with the steel, and also perhaps to the very fine condition of the slag covering the bath, due to the addition of glass during the blow.

As regards the manufacture of special steels, he did not think that this presented much difficulty, provided the additions required to obtain the necessary alloy were not too great. In making such steels, they had always made a very pure mild steel with carbon about 0.1, and then poured the melted alloys into the converter or put a portion in hot and added the rest molten. He had not had sufficient experience in the manufacture of this class of material to be able to speak with any authority to people who had studied this branch of the steel trade for so long a time as Sheffield steel makers, but he knew that such alloys as chrome-nickel, etc., could easily be made, and he believed that many of them could be made much cheaper in a converter of 10 cwts. capacity than in the crucible.

Discussion.

Professor Arnold said he had been seriously considering the "Stock" converter in connection with the steel works at Sheffield University. It almost seemed to him as if the maker of small castings was to be released from two enemies, the collier and the coke merchant. He believed the Stock process had come to stay.

Mr. L. N. Ledingham and Mr. Zanetti both spoke in praise of the process, the latter expressing the view that for small castings the "Stock" converter was almost ideal.

Mr. A. D. Ellis remarked that it was over 40 years since his father (Mr. J. D. Ellis), who was chairman of John Brown & Company, took out the first licence for the Bessemer process. There were great difficulties in inducing people to adopt the Bessemer process for the steel trade in Sheffield, but since then it had come into general use. Now they had a young aspirant, Mr. Stock, introducing an entirely new process, which would have made Mr. Bessemer's hair stand on end. He (the speaker) had had much experience of converters, and of all the difficult things in the world the worst was when a converter would not turn down; but Mr. Stock's was entirely under control, either mechanically or by hand. One of the great advantages also was that they had the mixture of metals entirely under control.

Mr. W. H. Hatfield wanted to know the relative costs in this and other processes. Professor Arnold told them that the process would rid them of two enemies—the collier and the man who sold coke—but he thought it would probably put them into the hands of one or other of the great oil companies.

A Member doubted whether the "Stock" furnace would be either desirable or economical in the case of a large output. It would do for small work, and he believed it would work successfully; but where a greater tonnage was needed he doubted whether it would do the work.

Mr. Stock, replying to the questions, said the pig-iron was added just the same as with the open-hearth. The carbon content on small castings was 0.2 per cent. The cost ran out at about 7s. per ton of finished steel in the ladle. The oil consumption on the finished steel, not on the metal charged, was about 30 gallons per ton.

Problems of Foundry Practice.

At the monthly meeting of the London Branch of the British Foundrymen's Association held on April 12th, since Mr. G. Hailstone was unfortunately not able to deliver his lecture on "The Application of the Microscope in the Foundry," which had been arranged, it was decided to promote a general discussion on practical foundry problems. In the absence of Mr. J. Oswald, Branch President, the chair was taken by Mr. J. Horne, the Vice-President. The discussion was brisk and interesting, a number of points of importance being dealt with.

Mr. A. R. Bartlett, of Messrs. Fraser & Chalmers, Erith, opened the discussion first by a brief address on "Unequal Thicknesses in Castings."

Unequal Thicknesses in Castings.

"One of the greatest troubles of the moulder appears to be that of the unequal thicknesses of the casting as designed by the draughtsman; and it is a trouble which is ever present, and has continually to be reckoned with. It is necessary with nearly every job to find some means of counteracting the drawing of the thick parts; for not only does the drawn hole in the thick part look bad, but a steam pipe or cylinder, or any other casting that has to stand a test, invariably leaks through the thick part, on account of the metal being more open in that place, unless closed by some means. There are many ways in which this drawing may be counteracted and the grain of the metal closed. The judicious use of chills will often serve, or possibly only a nail or two may be required to hold up and close the metal in a boss or lug. The draughtsman, too, may be approached, when he may be able to alter the design and place a core in the thick part, or otherwise reduce the quantity of metal so that the thickness is more uniform throughout. Often a core is left out by the pattern-maker because he thinks it will be difficult to get into its place; but it does not occur to him that in so doing he is causing trouble for the moulder. If the moulder were consulted at times by the pattern-maker and draughtsman it would save trouble all round."

Mr. Bartlett then proceeded to illustrate a number of castings which presented difficulties that might be overcome by the use of chills or altered design. Fig. 1 shows a flanged pipe with a leaky place in the filletted angle, while Fig. 2 shows a suggested remedy, the sudden change in thickness being avoided. Fig. 3 shows a steam chest cover ribbed across the top, which always cracked as marked. Chills were sometimes used in the angles with good effect, but the trouble was finally overcome by substituting the design shown in Fig. 4. A chill placed as shown in Fig. 5 was the

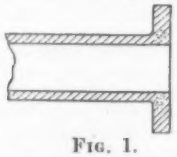


Fig. 1.

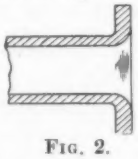


Fig. 2.

solution of another difficulty, while in the case of the boss shown in Fig. 6 a nail or two on the top often served to give soundness, or, failing that, a chill as shown. The plate with boss shown in Fig. 7 was liable to defects in the filletted corner, which defects were overcome by chills as shown.

Mr. Slater asked whether Mr. Bartlett thought that the application of pressure would obviate the troubles that were experienced by reason of unequal thicknesses in the casting.

Mr. Willis stated that the trouble of unequal thicknesses was experienced even more in brass than in iron, on account of the greater shrinkage. Much, however, could be done to overcome such dimculties by more frequent consultation between the pattern-maker and the foundry. Pattern-makers, as a rule, did not understand the laws governing the solidification of metals, or they would seek more to avoid making sharp corners on such parts as a boss standing out on a plate, or ribs. Thick and thin parts joining abruptly would inevitably give a place with weak crystallisation. The only solution was to have the pattern-maker well grounded in a knowledge of metallurgy, in addition to the general knowledge of foundry practice which most pattern-makers had. Otherwise it would be necessary for the foreman moulder to be always consulted on the design of the castings.

Mr. A. Whiting agreed with the previous speaker, but contended that the draughtsman was also to blame, since the pattern-maker was often simply carrying out instructions. If draughtsmen would more frequently walk through the shops and discuss with the moulder the possibility of improvements, both improvement in the castings and economy of produc-

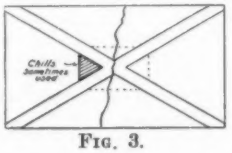


Fig. 3.

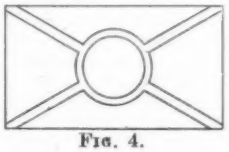


Fig. 4.

tion would result. In some cases, however, bad designs from the foundry standpoint could not be avoided, and in such cases much could be done by the use of chills to overcome the trouble resulting from unequal thicknesses.

Mr. Stone, citing his experience with malleable cast-iron, stated that chills with that metal were not always efficacious. Risers often broke the castings, and chills left spongy places underneath. Castings could often be made in grey cast-iron that could not be made in malleable, owing to the greater drawing and shrinkage of the latter. The difficulties mentioned however, could generally be got over by means of pressure.

Mr. J. Ellis stated that there was not the least doubt in his mind that sponginess in castings caused by unequal thicknesses gave more trouble than anything else. But as it was impossible for the designer to allow a uniform thickness in every casting, it was necessary to seek for remedies in other directions, such as feeding, chilling and closing up the grain of the metal by employing a good iron and using a very high blast. All foundrymen were not blessed with a variable-speed motor, which could be speeded up to meet this requirement, but the time was not far distant when this demand would be supplied. Mr. F. J. Cook was at present conducting a very exhaustive experiment in this direction, which should give some very valuable help towards minimising the real and serious trouble of spongy castings.

Mr. W. Ellis stated that he had had trouble through fillets being too large, the result being that drawing had occurred in the fillets.

Mr. Bartlett, in replying, said that pressure was very useful, but not efficacious in every case. Often chills also were necessary if the casting was of unequal thickness. In regard to a suggestion by Mr. Willis that more taper should be given to castings, it

was sometimes the case that excessive taper gave unequal thicknesses. Where trouble with sharp corners occurred, it was sometimes the practice for the moulder to insert a wedge in the mould and draw it when the casting had set, thus allowing contraction to take place. Pressure was more applicable to brass work than was the use of chills.

Runners.

Mr. Bartlett opened a discussion on "Runners," as follows:—

"One of the primary causes of bad castings is often the wrong position of the runner. The runner is considered by most moulders only as a means of getting the metal into the mould, and it is accordingly placed in any position, quite regardless of consequences. If there is plenty of room in the corner of the box, that is where the runner has to go. If there is no room in the corner or the side, it has to be dropped in, and this in cases where possibly, to ensure a good casting, the metal should be run in at the bottom; but this latter may mean more trouble, and if not insisted on by the foreman is not done. The disturbance of the mould by dropping the metal from the top is quite ob-

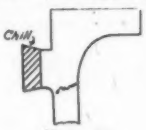


Fig. 5.

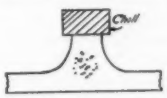


Fig. 6.

vious, and in the case of a green-sand mould the scabs are sometimes numerous, especially if the metal is dropped into a deep flange or bracket, in which case the metal naturally spreads and splashes up from the bottom of the mould, the same as water from a tap. If a job of this description were run at the bottom, the metal would flow in much quieter, and the risk of scabs would be greatly avoided. From experience of cylinders and similar castings, the writer always found good results follow the running of the casting from the bottom, no matter whether the cylinder were cast vertically or horizontally. Of course, the shape and size of the casting, and also the position of the cores decides where on the bottom the metal shall enter the mould. In the case of a large loam cylinder, where the centre core is bricked up on the bottom plate, it is usually most convenient to put the runner through the centre core. But in the case of a sand mould, as the core will most likely be made on a barrel, it is much more convenient to run the

Fig. 7.

metal in from the mould, either by the flange or preferably from underneath the flange and against the core in the print. Any dross on the metal is by this method naturally lifted into the head of the casting.

"Of course, there are many castings which on account of shape it is practically impossible to run anywhere but from the top. Take, for example, the majority of pulleys; they must of necessity be run in the boss, for not only is the rim too thin as a general rule to run the metal in, but the metal is more evenly distributed when run in at the boss. In fact, for this reason all wheels, of no matter what size, should be run from the centre. Any plate with a deep boss in the centre would of necessity have to be run from the centre, for the same reasons.

"A mistake that is often made when cutting a runner on a plate with a beading all round it, is to cut it in the joint and make the joint at the top, as in Fig. 8; the joint should be made level with the face of the plate as in Fig. 9, giving the metal a clear flow in and so avoiding the metal striking the top and pulling it down. Of course, a runner could be cut at each end of the mould, when it does not strike the top, but then there is the risk of the metal not making fast enough and the top being pulled down in consequence; or the casting may very likely be cold-shut in the middle of the plate, that is if it is a large one.

"A plate with ribs on it would usually be cast ribs down, unless it is necessary to get a clean face on the flat side; in the latter case it would be cast ribs up.

Fig. 8.

Fig. 9.

As a general rule the writer would endeavour to run the metal into the mould at the lowest possible point and rise it at the highest. But there are many exceptions to this rule; for instance, a cylinder liner cast on end, plungers and work of similar design, which can be very successfully run at the top and good results obtained.

"Sullage or dirt runners are very useful, if cut in a proper manner, in helping to get a clean casting. A few runners of this description are illustrated in Figs. 10 to 14.

"All runners should be large enough to run the casting quickly, for the quicker a mould is filled the better the casting will be, care always being taken to place the runners so that the metal has a clear flow, not striking cores or upright portions of the mould. No matter where the runner is, or how large it is, in making the runner up on the top of the mould it must be large enough to effectually choke the runner that is entering the mould so that it does not draw air and so that the dirt floats on the top of the metal in the runner box."

Mr. Worton, as opposed to Mr. Bartlett's suggestions, preferred to run castings from as near the top as possible. The casting should set at the bottom

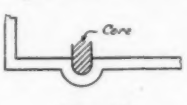


Fig. 10.

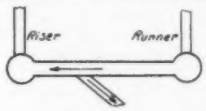


Fig. 11.

first and the top last in order to secure soundness. Bottom pouring tended to leave small contraction cavities in the bottom.

Mr. Stone considered that the best method of running cylinders was to have sullage runners with straight, flat runners.

Mr. Whiting remarked that every job required taking on its own merits. Runners on the top would serve as well as bottom runners for small cylinders; but for a large cylinder, such as, say, one 36 in. or 40 in. by 7 ft. or 8 ft. long, it was preferable to run from the bottom, as hotter metal could be used without the danger of damaging the mould which would accompany top running. For other work, if thoroughly dry, anywhere would do, the main object being to get the metal in as quickly as possible.

Mr. Bartlett, replying to Mr. Worton's remarks, considered that hot metal would meet the difficulty of the colder metal being at the top with bottom pouring. Top running was very liable to cause damage to the mould, especially with a big drop, since the metal would spread in falling and any bulging or projecting portions particularly would suffer. In very large jobs

it was better to go below the joint and rise to the castings.

Hot v. Dull Pouring.

Mr. Bartlett, having expressed the opinion that metal should be poured as hot as it could be got from the cupola:

Mr. Stone suggested that Mr. Bartlett's preference for hot metal was all very well for grey cast-iron, but in malleable cast-iron work to cast above a certain temperature was to incur not only drawing but cracking. A lower temperature would obviate both shrinkage and sponginess. Answering a question by Mr. Horne, the speaker said that the lower temperature mentioned did away with blow holes rather than caused them.

Mr. Wells said the temperature must be regulated by the nature of the job in hand. For hydraulic rams, for example, the metal should be as hot as possible; for cylinders it was better to keep the metal

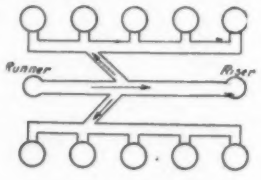


Fig. 12.

till the break on the top was observed. For work that had to be faced, however, he would have the metal as hot as possible.

Mr. Whiting: This bears out the contention that hot metal is the best for cleanliness.

Mr. J. W. Horne remarked that the hot metal allowed the dirt to rise better, but many foundrymen practiced dull casting owing to the danger of floating the cores with very hot metal.

Mr. Bartlett said that the heat at which the metal should be poured depended on the style of the casting.

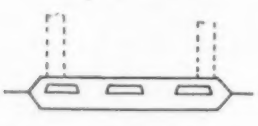


Fig. 13.

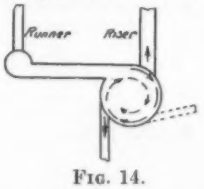


Fig. 14.

For a big, heavy job it was perhaps best to let the metal cool off, if no machining was to be done on the casting. But if the casting was destined for machining it was necessary to pour as hot as possible. The composition of the metal had also to be taken into consideration, since some metals cooled off very rapidly and would require to be poured very hot indeed.

Mr. Willis asked whether running a metal very hot would give more contraction? Would not a medium heat be better?

Mr. Bartlett replied that with bronzes a medium heat would be better, but not with iron.

Hot v. Dull Metal as the Cause of Scabbing.

Mr. J. Ellis opened an interesting discussion on the question of whether hot metal or dull metal was the more likely to cause scabbing in a green-sand mould. He cited the claim put forward by Mr. Robert Buchanan to the effect that scabs were more likely to result from dull than from hot metal.

"We have all had experience in this matter some time or other, and perhaps we have been too ready to attribute it to weak sand, or to too much sleeking closing the pores of the sand. Mr.. R. Buchanan has remarked that dull metal has the greater tendency to scab a mould. He has further said that as the dull metal enters a mould, it naturally wants to settle down on the sand, but is pushed along by the metal behind it; therefore the whole force of metal in the act of pouring is concentrated upon the sand under the first metal to enter the mould, hence the scab. On the other hand, hot metal will run into the mould very freely, and distribute itself much more readily, and will not scab a mould like dull metal does. Mr. Buchanan would not have made such a statement unless he had made exhaustive experiments, and was quite sure of his ground; but I very reluctantly, and perhaps doubtfully, say that my experience has been the reverse, and that hot metal scabs a mould more readily than dull."

Mr. Willis supported the latter view. Hot metal, he contended, generated gases in the face of the mould more rapidly than they could get away, and a series of miniature explosions occurred, shifting the face of the mould and causing scabs. If the mould was open in texture scabbing would not occur, but instead a sand-burn would be experienced, the metal biting into the face of the mould. If the face of the mould was sound enough to resist the metal, scabbing would be more likely to occur.

Mr. W. Ellis said that whatever the cause, the ramming of the sand to the correct hardness was the solution to the trouble.

Mr. Bartlett remarked that the observation of an open-sand plate casting would show that hot metal was more liable to cause the trouble mentioned. Ramming also affected it.

Mr. Stone also contended that dull metal would not scab as much as hot metal, but the distribution of the metal also had an influence. The excessive use of coal dust was a further contributory cause; too much coal dust and imperfect mixing would sometimes give streaks or veins on the casting, where the metal had eaten into the mould.

Mr. Whiting suggested that here again each job should be taken on its own merits, the thickness of metal and not the total weight being the governing factor.

Defects in Pipe Castings.

Mr. J. Batch then presented for solution a difficulty experienced with pipe castings. The pipes in question, ranging from 20 in. down to 4 in., were being cast horizontally, the metal being run in with several circular runners on the top. On the face of the castings, however, just under the surface and close to the runners, small round holes about the size of peas were found. The pipes had been tried run from the end, straight in close to the core, but spongy places in the flange had resulted. The metal was as hot as possible, straight from the furnace. The holes in question had not the characteristics of draw-holes, but were bright and clean inside, and suggested to him that sulphur was the cause.

Mr. Whiting suggested that the runners had not been kept open properly. He expressed a preference for running on end on a bank, and did not favour running pipes at the top.

Mr. Bartlett remarked that similar trouble had been overcome by using flat, thin runners, say 3 in. by $\frac{1}{4}$ in. and proportionate sizes according to the casting, instead of circular runners. He preferred to run such castings at the end by the side of the core. Possibly in the case cited the core was not open enough. He generally mixed loam more open for a barrel core than for other work.

Mr. Willis suggested that the holes were formed by air bubbles.

Mr. J. Ellis recalled the fact that in casting tur-

bine casings, he had put runners on top, and often holes, such as mentioned by Mr. Batch, would appear when the runners were cut off. They were quite clean and bright. It was curious they should be in that particular spot when it was considered that something like three tons of metal passed through the runners, and that when the mould and runners were filled there was plenty of room for the gases to ascend through the liquid metal. He considered that the best method was to run pipes of that description in the middle on the joint, using chills at the flanges, and to have the metal as hot as possible and dash it in very quickly.

Mr. Horne denied that sulphur to the extent experienced in cast-iron caused blow holes, since it was generally present below 0.2 per cent. in amount. If more than that were present it would indicate bad coke, the use of which would certainly not pay. It was a practical impossibility for sulphur up to 0.2 per cent. to cause blow holes. They might be due to other gases, in which oxygen would be found.

A Member remarked that the fact of a thin runner preventing such defects would indicate that drawing was at the root of the trouble. He suggested a runner shaped like a top to solve the difficulty in question.

A Core Trouble.

Mr. Worton exhibited part of a core which had caused great trouble in a bed-plate. The core in question was T-shaped, in a large casting, and as cast was at the bottom of the mould. The metal had eaten into the core to such an extent that the latter resembled iron (in fact, on analysis, it was shown to contain 42 per cent. of iron) and offered great resistance to a chipping tool used to remove it. The core mixture was as follows:—3 parts dried loam; 1 part horse manure; ¾ plumbago; 5 new Erith sand.

Mr. Whiting said he had seen the casting in question and could only say that the core was too weak and the metal too hot.

Mr. Bartlett suggested a solid core of ground yellow loam, not vented, and the use of "Glutrine" as a binder. The metal should be run cooler at the bottom and rise to the top.

Alloys of Aluminium and Zinc.

At a meeting of the Institution of Mechanical Engineers, held at the Institution Building, Storey's Gate, Westminster, on Friday last, Dr. Walter Rosenhain and Mr. S. L. Archbutt, of the National Physical Laboratory, presented the Tenth Report to the Alloys Research Committee of the Institution, on the "Alloys of Aluminium and Zinc." The Report in its entirety is a voluminous affair, with tables and plates and an appendix on a ternary alloy of aluminium with zinc and copper, but a Summary, from which we take the following, has been prepared by the authors, and issued by the Institution:—

The Ninth Report to the Alloys Research Committee contained an account of the influence of manganese upon the alloys of copper and aluminium; the consideration of manganese was regarded as the first step in a general investigation of the ternary alloys of copper and aluminium with other metals, and the Alloys Research Committee decided that the next step in this investigation should deal with the effect of zinc. As it had been found, however, that the previous Reports dealing with the useful alloys lying at both ends of the copper-aluminium series were undesirably bulky, it was decided in the first place to confine the investigations to alloys consisting principally of aluminium, which may be conveniently grouped under the term "light alloys."

Before the systematic study of the ternary alloys of aluminium, copper and zinc could be undertaken it was, however, necessary to investigate the new base-line of this system, namely, the alloys of aluminium and zinc. In practice the investigation of the binary alloys and of the ternary alloys derivable from them has been carried on side by side, but the well-known difficulty which arises in all investigations of ternary alloys from the large number of combinations which have to be studied has made it desirable to publish the results of the investigation of the binary alloys without waiting for the completion of the study of the ternary system. The present Report, therefore, deals principally with the constitution and properties of the binary alloys of aluminium and zinc. At the same time the investigation of the ternary system has already been carried to a considerable extent and has revealed the existence of a group of alloys which promise to be of considerable practical value. While, therefore, it is impossible to publish a systematic report on the ternary system at the present stage, an Appendix has been added to this Report in which some of the more remarkable results already obtained for certain of the ternary alloys are stated.

From the point of view of practical use, the aluminium-zinc alloys have received considerable attention. For casting purposes the fact that an addition of zinc to aluminium facilitates the production of sound castings is widely recognised; at the same time, these alloys are credited with undesirable properties in two important directions. The first of these is the tendency which they are said to possess to crack in cooling, particularly if the castings are of a shape liable to that form of defect. Further, the alloys are generally regarded as being liable to rapid corrosion, and actual examples of such corrosion have come under the notice of the present authors in the case of industrially-prepared alloys. The experience of the authors, however, in dealing with these alloys does not confirm these widely-held views of their properties; the authors have had no difficulty in avoiding the cracking of castings which is said to be due to the tenderness of these alloys when hot. As regards corrosion, the experiments and tests described below indicate that the alloys as prepared by the authors are by no means liable to the severe and excessive corrosion which the general reputation of the alloys would lead one to anticipate. The authors supposed—and experiment has justified the supposition—that the rapid corrosion (particularly in moist air) of many commercial samples of aluminium-zinc alloys is due to the presence of impurities derived from the spelter employed in their manufacture. The authors' alloys, prepared from pure zinc, behaved in a much more satisfactory manner.

With regard to the mechanical properties of the aluminium-zinc alloys, the statement is sometimes found that they are particularly weak under the action of vibratory stresses and of shock. Here again the results of the present research do not confirm this previously-held view; the exhaustive tests under shock and alternating stresses described in this Report clearly show that these alloys are not abnormally weak in this respect, and that in effect they exhibit properties in these circumstances which are in normal correspondence with their general mechanical behaviour.

As regards the general mechanical properties of the aluminium-zinc alloys, the outstanding result of the present research is perhaps to be found in the very large effect produced upon them by hot work. It has been

found possible to roll out into bars and even to draw into wire an alloy containing as much as 25 per cent. of zinc, in spite of the fact that this same alloy in the sand-cast condition shows no perceptible ductility. This alloy attains its maximum tensile strength when in the condition of rolled bar 1¼ in. in diameter, the maximum stress being 27.5 tons per square inch. It is very interesting to find that rolling down the same alloy to ⅜-in. diameter while hot, so far from improving the properties of the material, brings about a reduction in the tensile strength of several tons per square inch, and similar phenomena are met with throughout the whole series of alloys. It may be added here that by the addition of a small percentage of copper to these aluminium-zinc alloys, as indicated in the Appendix to the present Report, the tensile strength of the hot-rolled material may be raised to 32 tons per square inch while retaining a reasonable degree of ductility. In the form of wire the maximum tensile strength obtained is 34 tons per square inch. The specific gravity of alloys having these high tensile strengths lies in the neighbourhood of 3.2, so that they may still fairly be regarded as light alloys; in comparison with other light high-tensile alloys containing magnesium, the present series have the advantage that no special heat treatment or quenching is required to develop their special properties.

Both the binary and ternary alloys just referred to differ in one important respect from the majority of non-ferrous alloys by the fact that in the rolled condition they exhibit a definite and well-marked yield-point, their behaviour in the testing-machine showing the sudden dropping of the beam which is familiar in the tesing of mild steel. This behaviour may perhaps justify greater confidence in the properties of these alloys than that which engineers usually repose in materials having a gradual indefinite yield.

If the results of the present investigation are viewed in the light of current practice in the application of aluminium-zinc alloys, the most important point is that the alloys richer in zinc, namely, those containing from 15 to 25 per cent. of zinc (with or without the addition of copper), are deserving of much closer attention and of more widespread use as compared with the lower alloys, containing less than 15 per cent. of zinc, which are much more widely used in present practice. If dynamic as well as tensile tests are taken into consideration, the outcome of the present Report is to show that the alloy containing 20 per cent. of zinc is the most generally useful of the simple binary alloys.

In this brief notice of the outstanding results of the investigation mention must now be made of what is probably the most serious defect of this group of alloys, namely, their great sensitiveness to rise of temperature in relation to their tensile strength. Thus the alloy containing 25 per cent. of zinc, whose tensile strength at the ordinary temperature is 27.5 tons per square inch, at a temperature of 100 deg. C. has a tensile strength of only 18.5 tons per square inch, and the rapidity of this drop in strength with rising temperature increases as the temperature is further raised. When very hot the alloys are accordingly very weak, but while they are brittle to shock and cannot therefore be forged at temperatures much above 400 deg. C. (752 deg. Fahr.), in the testing machine they still exhibit an exceptional amount of ductility. It is this somewhat abnormal behaviour which makes it possible to roll into bars alloys which are brittle in the cast state, but at the same time it renders an accurate control of the rolling temperature an essential condition of success.

Summary of the Principal Results.

The principal results obtained in the investigations described in the present (Tenth) Report to the Alloys Research Committee are briefly summarised as follows:—

(1) *The Constitution of the Alloys.*—This is only briefly dealt with in the Report, since a full account of the metallographic study of the aluminium-zinc system has already been published elsewhere. The new equilibrium diagram arrived at by the authors is reproduced, showing the occurrence of reactions and the formation of a definite compound (Al_2Zn_3) whose existence had not previously been established. From the equilibrium diagram it appears that all the alloys containing more than 40 per cent. of zinc undergo transformation at a temperature of 256 deg. C. (493 deg. Fahr.). As regards the alloys at and near the aluminium end of the series, the new equilibrium diagram establishes their "solidus curve" or temperature of complete solidification, and also exhibits certain minor transformations which, although shown not to be due to a change in the pure aluminium-zinc system, always occur in commercial alloys at temperatures near their melting-point. The alloys containing less than 40 per cent. of zinc are shown to be simple homogeneous solid solutions, although it is possible that the inversion of 256 deg. C. also occurs at this end of the series. When cast in chill moulds, the microstructure of these alloys exhibits the sharply "cored" structure usually found in rapidly cooled solid solutions having a long range of solidification. In sand-castings this coring is less sharply defined and the whole microstructure is on a larger scale. The "cores" are entirely removed by prolonged annealing at such a temperature as 400 deg. C. (752 deg. Fahr.), but they are removed rapidly and completely by the rolling process. Photomicrographs of the hot-rolled alloys, especially after annealing, containing up to 25 per cent. of zinc, exhibit the typical polyhedral structure of a perfectly homogeneous solid solution, although the scale of the crystals varies considerably according to the exact mode of treatment which the material has undergone.

The Study of the Cast Alloys.—Tensile tests on sand and chill-castings of a series of alloys covering the entire range of the binary system are given, both in tabular and graphic form. The tensile strength of sand-castings shows a steady increase up to a concentration of 50 per cent. of zinc, when an ultimate stress of 18.7 tons per square inch is reached; there is then a slight fall of strength with further increase of zinc-content, followed by a rise to a second maximum near 75 per cent. of zinc, a concentration which corresponds approximately to the composition of the compound Al_2Zn_3. The highest ultimate stress reached is 18.9 tons per sq. in. The table and curve representing the results of tests on chill-castings is somewhat different in type, three maxima being observed, namely, the first at 30 per cent. of zinc with an ultimate stress of 17.9 tons per sq. in., the second at 50 per cent. with 21.6 tons per sq. in., and the third at 75 per cent. with 20.1 tons per sq. in. The yield-points for both sand and chill-castings are recorded as observed, but the observations were found to be somewhat uncertain in the case of the cast alloys.

In discussing the results of tensile tests on the present series of alloys the authors have used the term "Specific Tenacity," to denote a quantity which is proportional to the tensile strength and inversely to the specific gravity; this has been calculated by dividing the ultimate stress of a given alloy in tons per sq. in. by the weight of a cubic inch in pounds. The quotient is the breaking load in tons of a bar of the material whose cross-section is such as to make the weight of the bar 1 lb. per in. length. From the point of view of tensile strength alone this figure may be regarded as representing the value of any structural material, and allows of comparisons on a correct basis between materials of widely different specific gravity, such as these light alloys and steel. In the cast alloys the specific tenacity is found to reach its maximum for both sand and chill-castings in an alloy containing approximately 26 per cent. of zinc. The value attained is just over 150, as compared with a maximum value of 126 reached by the light alloys described in the Ninth Report. In the light alloys of aluminium with copper alone the specific tenacity of casting does not exceed a value of 99.

Compression tests on a number of chill and sand-castings of the alloys, including some of higher zinc-content, have been made. These tests show that in general terms the behaviour of the castings under compression is approximately proportional to their behaviour under tension. The highest yield-stress under compression was obtained with alloy No. 55 in the chill cast condition, giving a stress of 22.96 tons per sq. in. It is curious to find, however, that the chill-castings

are decidedly inferior to the sand-castings until a zinc-content of about 50 per cent. is passed.

The question of the possible "ageing," or even gradual spontaneous disintegration of the aluminium-zinc alloys has also been studied in connection with the sand-cast material, tensile tests of some of the alloys being repeated on specimens which had been kept for over fifteen months, but no signs of any change were observed.

Study of the Wrought Alloys.—Billets of the alloys containing up to and including 26 per cent. of zinc were cast at the Laboratory and were rolled and drawn to various sizes, including wire and sheet, at the Milton Works of the British Aluminium Company. Hot-rolling was found possible with all these alloys, but not with an alloy containing 30 per cent. of zinc.

Tensile tests on a representative series of alloys lying between the limits of composition just named were made on material in the form of (1) bars hot-rolled to 1¼ in. diameter, (2) bars hot-rolled to ⅞ in. diameter, (3) bars hot-rolled to ½ in. diameter, (4) bars cold-drawn to ⅜ in. diameter, (5) bars drawn with annealing to ⅜ in. diameter, (6) cold-drawn wire 0.1285 in. diameter, and (7) sheet of 0.14 and 0.07 in. thickness. In addition, the material in the form of ⅞ in. bars hot-rolled, ⅝ in. cold-drawn, hot-rolled ½ in., and wire, as well as sheet of both thicknesses, was also tested after annealing for one hour at 400 deg. C.

The condition (excluding wire) of highest tensile strength, together with the yield-stress and elongation corresponding to that condition, are given for a series of typical alloys in Table I.

TABLE I.

No. of the Alloy (also per cent. Zn).	Condition for Highest Ultimate Stress.	Ultimate Stress.	Yield-Point.	Elongation on 2 inches.
		Tons per sq. in.	Tons per sq. in.	Per cent.
5.. ..	⅞-in. hot rolled bar	8.94	7.4	26
9.. ..	⅞-in. hot-rolled bar	11.17	6.98	38*
11.. ..	⅞-in. hot-rolled bar	13.78	9.42	35*
13.. ..	⅝-in. cold-drawn bar	14.73	12.80	19.5
17.. ..	1¼-in. hot-rolled bar	19.85	13.20	22
20.. ..	1¼-in. hot-rolled bar	22.64	17.3	20.5
26.. ..	1¼-in. hot-rolled bar	27.09	25.00	16.5

* On 1 inch.

Tensile tests at high temperatures were made on a series of the alloys in order to ascertain the effect of zinc-content on the rate of loss of strength of these alloys with increasing temperature. Most of the alloys were tested up to 200 deg. C. (392 deg. Fahr.), but in two cases considerably higher temperatures were employed (up to 595 deg. C.). In every case it is found that there is a rapid fall in the yield-stress and ultimate stress with rising temperature, even 50 deg. C. producing a marked effect. The rate of loss of strength varies according to the composition of the alloy; thus at 100 deg. C. the alloys containing up to 13 per cent. of zinc have lost about 36 per cent. of their tensile strength at the ordinary temperature; the alloys containing from 15 to 17 per cent. show a loss of 44 to 52 per cent., but this figure again diminishes to 26 per cent. for alloy No. 26. These relative rates of loss are confirmed at higher temperatures. At still higher temperatures the strength of the alloys becomes exceedingly small, but they exhibit a remarkable degree of ductility as measured by elongation and reduction of area; the latter in some cases is so great that the fracture is drawn down to a sharp point, while the elongation in one instance reached 133 per cent. Forging tests, however, show that this extreme ductility exists only under "static" loads, and that the alloys which draw out to fine points in the testing machine are broken into small fragments if struck sharply with a hammer at the same temperature.

The elastic properties of the alloys have been determined both for the hot-rolled and cold-drawn materials. They exhibit a satisfactory elastic behaviour and show well-defined elastic limits, which increase regularly with the zinc-content and consistently with the ordinary yield-point determinations. The elastic moduli of all the alloys are almost identical, lying near the value 9×10^6, a low value which may prove a disadvantage for certain possible uses of the alloys.

Torsion tests have been carried out on specimens cut from the alloys in the form of 1¼ in. hot-rolled bars; comparison of the results with those of tensile tests shows that the torsional strength, although it increases considerably with increase of zinc-content, yet does not increase as rapidly as the tensile strength. The ratio of the maximum stresses under the two forms of test falls from 1.10 for alloy No. 9 to 0.76 for alloy No. 25.

Compression tests have also been made on the wrought alloys. The results are in strict conformity with those of tensile tests, although the compression yield-stresses are always slightly higher than those found in tension.

Dynamic tests have been carried out on the alloys. The tests in alternations of direct stress give a series of results for the safe range of alternating stresses for the alloys, and this curve lies considerably below that of the static elastic limits. These ranges, although low when compared with the ordinary tensile test results, yet indicate a very decided advance on other light alloys which have been described in the Ninth Report. The best of those alloys (of aluminium with copper and manganese) showed a safe range of 9.4 tons per sq. in., while the best of the present series has a range of 12.0 tons per sq. in.

Alternate-bending impact tests were made with a weight of tup of 4.71 lbs. and heights of fall of 1.0 in. and 0.71 in. respectively. Both sets of tests give curves of very similar shape which show that after 15 per cent. of zinc the resistance to this test is strictly proportional to the zinc-content of the alloy. Of the present alloys, No. 9 shows a resistance practically equal to that found in the best of the light alloys described in the Ninth Report (about 600 blows with a fall of 0.71 in.), while the best alloy of the present series (No. 25) required 3,400 blows for fracture. This power of resisting repeated impact is particularly noteworthy in view of the fact that the aluminium-zinc alloys are frequently spoken of as being weak under shock.

Single-blow impact tests, made on the Izod machine, show that the work absorbed by fracture reaches a maximum for a zinc-content lying between 15 and 20 per cent. This is in accordance with the fact that such tests are affected by both tensile strength and ductility, so that the increased tensile strength of the alloys containing more than 20 per cent. of zinc is more than outweighed by their lower ductility so far as this test is concerned.

Under Professor Arnold's alternate-bending test, the alloys gave remarkably uniform results, but the curve of number of alternations endured falls rapidly with increase of zinc. Professor Arnold remarks that the resistance of these alloys to his test varies from ⅛ to ¼ that of the heat-treated best mild structural steel. It is interesting to note, in comparing the results of the three last-mentioned forms of dynamic test, that the curves representing their results are closely related to the curves of ultimate stress and elongation or reduction of area as shown by tensile tests. Thus the repeated-bending impact tests give a curve which is closely proportional to that of ultimate stresses, while the results of Professor Arnold's tests are proportionate to the ductilities of the alloys as shown by elongation or reduction of area. The single-blow impact tests, on the other hand, appear to be proportional to the sum of these two properties.

In view of the results of all the mechanical tests the authors arrive at the conclusion that an alloy containing about 20 per cent. of zinc probably represents the best combination of properties obtainable in the simple binary aluminium-zinc series.

A general feature of some importance in connection with all the alloys described in the present report, and particularly with those containing from 10 to 30 per cent. of zinc, is the great facility with which they can be worked by machine tools of all descriptions, in most cases without the use of any lubricant.

Foundry Plant and Equipment.

The Hewlett Core Machine.

A core-making machine of the type in which the sand is rammed into the core box by air pressure is being manufactured by Messrs. Wm. Demmler & Bros., Kewanee, Illinois, U.S.A., who have recently placed on the market an improved design. This is illustrated herewith.

As regards the operation of this machine, the sand is placed in the cylindrical holder shown in the foreground of Fig. 1, from which it is carried by a simple elevator to the upper sand hopper located at the top of the machine. The holder has a capacity of three cubic feet. The sand is fed to the elevator by a graduated feeding device which can be regulated to furnish the proper quantity for cores of any size. From the upper hopper the sand passes into the lower or feeding hopper, H, which is secured to the under side of a sliding plate, X. This plate is worked slowly backwards and forwards by a crank and link-work attached to the fly-wheel. When the plate, X, is at one end of its stroke, hopper H is in communication with the upper hopper and is filled; when the plate is at the opposite end of its stroke, compressed air is admitted to the hopper through the valve, V. The hopper, which is then directly over the core box held in the chuck on the table, T, has a flat plate across the bottom through which two small holes are drilled. The pressure of the air forces the sand through these holes into the core box. If the upper surface of the core is flat, this plate serves for the top of the core box; if the core is irregular, the box is closed on top, two holes being left for the admission of sand through the bottom of the feeding hopper.

The table, T, is adjustable and is provided with an automatic compressed air chuck which holds the core boxes securely while they are being filled and releases them as soon as the operation is completed. The valves controlling the admission of air to the chuck and feeding hopper are operated automatically by cams on the flywheel.

The sand in the upper hopper is prevented from sticking by a revolving cutter. The machine is driven by a belt to a 16-inch clutch pulley running about 30 revolutions per minute. The fly-wheel, to which the crank and cams are attached, is so geared to the clutch pulley that it operates about eight revolutions per minute.

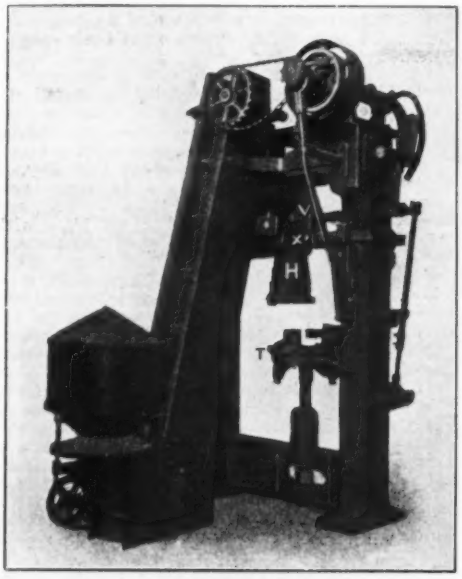


FIG. 1.—HEWLETT CORE MACHINE, WITH SAND CONVEYOR.

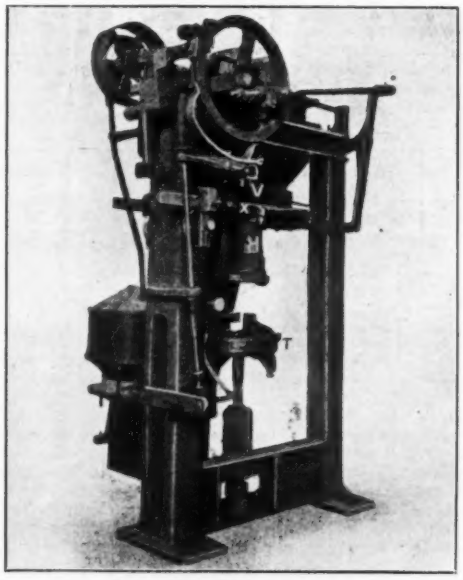


FIG. 2.—CORE MACHINE, SHOWING HOPPER AND TABLE.

The sliding plate, X, carrying the feeding hopper, therefore, makes about eight strokes and fills eight core boxes every minute. There may be several cores in each box. The frame of the machine is cast iron, box section, and is about 6 ft. 6 in. high and 5 ft. wide. The floor space required, including the elevator, is, approximately 30 sq. ft. Cores of very irregular shape can be made as easily on the Hewlett machine as plain ones, the air forcing the sand into pockets and angles in the core box.

In operating the machine, 80 lbs. per square inch air pressure is required for oil and silica sand mixtures; 90 lbs. for oil mixtures containing loam, while mixtures using resin, glutrin, or flour require 100 to 115 lbs. pressure. The machine requires one horsepower to drive it, and consumes about 12 cubic ft. of free air per minute. It will make cores from 1 in. to 15 in. in length, and will fill boxes using as much as 200 cubic in. of sand.

Moulding Machines for Mower Parts.

The illustrations shown herewith (Figs. 1-3) depict two moulding machines recently made by the International Moulding Machine Company, of Chicago, Ill., U.S.A., for agricultural implement parts. The machines were especially designed for the work. Figs. 1 and 2 show a machine for moulding for the wheels of mowing machines, while Fig. 3 illustrates one employed in connection with the production of the frames of machines.

Referring to Figs. 1 and 2, this machine is entirely encased to prevent obstruction of the working parts, by sand falling upon them. When the pattern and the stripping plate are properly located in the machine there are no openings in which the sand can enter and lodge. The casings of these wheel machines are fitted in such a way that when necessary they can be readily opened, as shown in Fig. 2, for oiling or inspection. The drag portion of this machine is operated as a turn-over machine, or, in other words, after the mould has been rammed up, the bottom board is clamped on and the complete equipment is picked up by a quick-acting travelling crane, turned over and moved along and set down on the floor. This arrangement has been employed to obviate the necessity of barring the flask and turning the mould over after it has been made. After the pattern has been drawn the machine is lifted off and turned back to its original position. In this way there is no danger of the mould being damaged, as the pattern remains in it while it is being moved preparatory to turning it over, or while it is being carried along the floor to the place at which it is to be set down. The height from the floor to the top of the frame in this machine is only 17½ in. The design and the arrangement of the crank and other working parts is such that they operate within this comparatively small space without interfering with the pattern, the stripping plates or the stools.

The machine illustrated in Fig. 3 conforms strictly to the outline of the pattern, and, consequently, is of a very irregular design. This construction was employed in order that there might be no superfluous sand to ram, and, as a result, the patterns and the stripping plate extend beyond the ends of the machine frame. The casings cannot, therefore, be fitted to this machine until the mounting is finished, but when this is completed they are attached to the stripping plate at the top and to the base plate of the machine at the bottom, as indicated. When this has been done the machine is encased as completely as the one employed for producing the wheel patterns. The yoke to which the pattern is attached is cut down or filled up according to the plane of the parting line, to eliminate all unnecessary time and expense in fitting the pattern. This machine operates on exactly the same principle as the other, and the height is the same, 17½ in. from the floor to the top of the frame.

Each of these machines requires eight men to operate it: three for ramming up the cope and three for the drag; one man to handle the crane and the eighth to set the cores and assist the crane man. The flask used on the wheel machine is 9¼ in. deep and has an internal diameter of 36 in. The eight men, who are only ordinary labourers, produce from 250 to 260 wheel moulds and 135 frame moulds per day.

A Large Jarring Moulding Machine.

Herewith illustrated is a large jarring moulding machine, recently installed in the iron foundry of the Mesta Machine Company, at West Homestead, Pittsburgh, Pa., by the Herman Pneumatic Machine Company. The table-plate of the machine is 8 ft. by 12 ft. and the base is of about the same dimensions. The cylinder is 40 inches in diameter, with a lifting capacity of 120,000 pounds. The base consists of a one-piece iron casting and the table-plate is of cast steel.

FIG. 1.—MACHINE FOR MOULDING MOWING MACHINE WHEELS.

FIG. 2.—MACHINE CASING OPENED FOR INSPECTION AND REPAIRS.

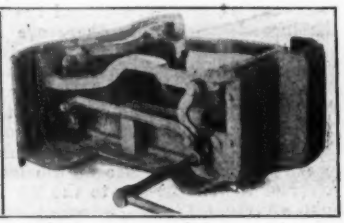
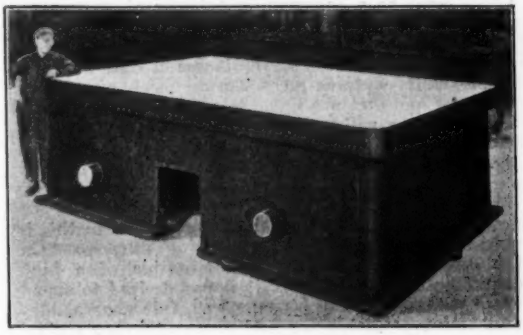


FIG. 3.—TYPE OF MACHINE FOR MOULDING FRAME PATTERNS.

The operation of the machine is controlled by an automatic self-control valve, which consists of a top and bottom head, double check valve stem, differential piston and body. All operating parts are inside of the body, and the only opening consists of an inlet, the port to the cylinder and the exhaust to the atmosphere. The seat is so arranged that the valve may be easily re-ground. The valve is constructed in such a manner that makes it possible to consume only a sufficient amount of air in order to lift the load, so as to produce the number of blows per minute required to ram the mould. The valve is situated directly against the port of the cylinder, to give the greatest efficiency.



LARGE JARRING MOULDING MACHINE.

D

Two guides, 14 in. long each, are on each corner of the table-plate. These guides are cored out so that the holes may be filled with waste and oil for lubrication. The same number of wearing plates to meet the guides are located in the base, and the same method of lubrication is provided. The cylinder is oiled by means of a tube projecting through the base.

The table-plate is strengthened by tension and compression ribs. The plunger is one piece of cast steel bolted securely to the table-plate, and is fitted with expanding packing rings. There are thirty resilient jarring blocks, equally distributed about the top of the base. These have a combined surface of 590 square inches. The table-plate is provided with the same number of bosses as the jarring surface, and in operation it falls on these jarring discs, the shock of which forms the mould. The resilient surface in the base, which is a feature of the Herman moulding machine, is claimed to eliminate all danger of moulds dropping due to vibration.

Electric Lighting for Foundries.*

By B. G. Worth.

There are three kinds of lamps to be considered: the incandescent, the arc, and the vapour lamps. Of the incandescent lamps there are the ordinary carbon, the metallised carbon, the tungsten, and the Nernst lamp. Of the arc lamps there are the enclosed carbon, both alternating and direct current, the long burning flame arc, and the luminous arc. The vapour lamps, that is, the Cooper, Hewitt, and the Moore lamps, are not considered adapted to foundry lighting because of the lack of penetrative power of their light due to the low intensity of their light sources.

Foundry lighting must not be too uniform in its character, as shapes of moulds are difficult to see, due to the darkness of the material and the consequent fact that shadows are not so apparent as on lighter materials. If the illumination is too uniform the mould will appear flat. Again, moulds contain deep recesses into which the light must penetrate, and unless there is considerable direction to the light rays it will fail to penetrate into the interior of the mould. This condition is more or less opposed to the condition requiring shadows, as the rays should be oblique to make shadows and should be vertical in order to see the inside of the moulds. There must be a compromise between these two requirements.

Another thing which must not be lost sight of in a foundry is the effect on the lamps of dust and gas. If the lamp contains an elaborate mechanism, then the gases and dirt are liable to affect this mechanism and the lamp will not be always in working order. If it has a complicated system of shades, or diffusers, these become dirty and a large part of the light is cut off.

The best way to get a good illumination is by general lighting of a high character, and then this is naturally also available for pouring purposes. On the other hand, a general illumination of a high character is expensive. If it is not desired to spend much money, this can be done by a fair general illumination provided in the first place, and then special localised illumination provided where it is required for good work. This compromise is not altogether satisfactory, because practically the only way to provide the special illumination is by the use of extension lamps. These are a nuisance, as they clutter up the floors and wear out rapidly, and are always a source of trouble and maintenance. If capital is available it is much better to provide a general illumination.

The amount of illumination required ranges from about ½ ft. candle to 3 ft. candle. One-half foot candle is very low, and is just sufficient to enable large work to be carried on. On the other hand, 3-ft. candle is very good illumination, and would be sufficient under certain circumstances for a reading room. Such good light may be considered extravagant, but it is not in fact, because light goes a great deal farther in a reading room, due to the good conditions, than it does in a foundry.

Somewhere between the two extremes is the proper amount, and this must be determined by the character of the work. For foundries working on large, heavy castings where finish of the mould is of not much importance, about 1-ft. candle should be sufficient. On the other hand, in foundries casting small objects requiring great detail and careful finish of the mould 3-ft. candle is none too much. This question of the amount of illumination is one of the most vital points to be considered, inasmuch as it determines the cost of installation and operation of the whole system.

There are two methods of getting at the amount of candle-power capacity necessary. One is the flux of light method, and the other is the step-by-step method. The latter is, in the writer's opinion, the best for foundry work. This method consists in assuming a certain arrangement of lamps and certain positions or stations in the foundry, and calculating the illumination at each station. These calculations, although tedious, are easily made from the distribution curves of the lamps in question. Of course, this method involves considerable labour, because several tentative plans must be worked out. After working out these plans, however, it will be possible by inspection to decide just about what is wanted.

Lamps, of necessity, must be hung above the crane in order to permit its operation, and for this reason it is not feasible to use small units, as the number required brings the cost per unit of light up very high. Thus it works out that in general high-power lamps, such as arcs, can be used to the best advantage. These lamps, in order to avoid glare, and secure good distribution, should be hung very high. As it is difficult under these circumstances to clean and adjust lamps, the cost of trimming becomes serious unless a long-burning lamp is used. The flame arc is probably the most efficient solution of the foundry lighting problem. It is the most efficient source of lighting known. It can be used on both alternating and direct current. Certain makes are suitable for multiple work, *i.e.*, each lamp can be operated separately and controlled. Its light has penetrative power. The only objection to the lamp is that its mechanism is more or less complicated in the types which have the highest efficiency. Some less efficient types, however, have mechanism which is the acme of simplicity. While flame lamps throw off a certain amount of gas, this is of no consequence in a foundry and can be neglected.

In some small foundries and in old ones where the ceilings are not high it will be impossible to use the flame lamp, because it is of a size which needs to be hung high to get the distribution. These foundries must come to a smaller unit. The flame-arc lamp, because of certain inherent features, cannot be constructed in very small units, and it then becomes a choice between a luminous arc lamp and an incandescent. The luminous lamp is midway between the flame and the incandescent, and has all the good qualities of the flame lamp, except its mechanism is more complicated, and it cannot be used on alternating current.

* Abstract of Address delivered before the Newark Foundrymen's Association, Newark, N.J., March 1, 1912.

Inventions.

Applications for Patents.

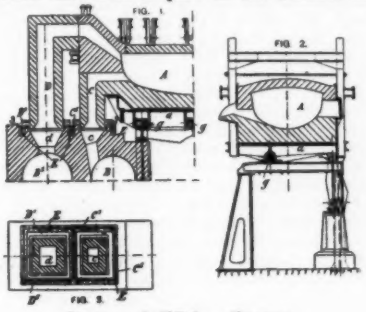
An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

7,203. Furnaces for heating copper ingots. G. B. A. Gibbons and R. Masters.
8,479.*Refining process for iron and steel by means of ferro-chrome alloy. J. Büchel.
8,485. Producing bars, tubes, etc., directly from molten metal. A. H. Pehrson.
8,486. Pyrometers. F. Rogers.
8,578. Producing bars, tubes, etc., directly from molten metal. A. H. Pehrson and J. W. Löf.
8,579. Electric induction furnaces. H. G. Solomon.
8,706. Moulding machines. E. Müller.
8,708.*Grinding machines. (Norton Grinding Company, United States.)
8,709.*Cylindrical grinding machines. (Norton Grinding Company, United States.)
8,768. Moulds for casting metals and alloys. J. Shanks.
8,791.*Electric arc furnaces. (Patents Purchasing Company, United States.)

Abstracts of British Patent Specifications recently accepted.

6,808 (1911). *Manufacture of Steel.* F. W. Paul, Grand Hotel, Glasgow.—Assuming that the total quantity of the charge of pig-iron and steel scrap amounts to 60 tons, consisting of approximately 40 tons of pig-iron and 20 tons of steel scrap, an initial fractional part of the 40 tons of pig-iron, say 12 tons, is charged on to the bottom of the furnace as soon as the tapping hole of the furnace is closed from the previous tap. The repairing of the upper banks of the furnace is then proceeded with, and as soon as this is completed, the first instalment of pig-iron is brought to the molten condition. Thereafter from time to time, at intervals, for instance, of 30 to 60 minutes, further instalments of from three to six tons of pig-iron are added, the amount of the additions and the rate at which these are charged being such that the greater part of the contents of the furnace is in liquid form throughout the charging operation, the amount and rate of each addition being dependent, for instance, on the melting capabilities of the furnace, and the mechanical appliances or manual labour available for handling the charge. Concurrently with the charging, or at different times, there is added to the charge iron ore or scale in such quantity as to approximate to what is theoretically required to eliminate the silicon, manganese, phosphorus. In practice four to six tons of oxide of iron will suffice for the desiliconisation, etc., of the 40 tons of pig-iron, such oxide of iron being preferably added in instalments corresponding to the fractional charges of pig-iron put into the furnace. When dealing with white iron or pig-iron approaching thereto, that is containing a small percentage of silicon, it is preferable to add about 20 cwts. of broken or molten open-hearth slag, which may act as a protective coating to the bath of metal. The addition and quantity of limestone to be added during the charging, melting and desiliconising, etc., period is dependent on the class of pig-iron and ore used.

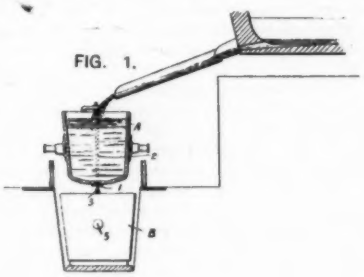
637 (1912). *Tilting Martin-Siemens Furnace.* Ateliers de Constructions Electriques du Nord et de l'Est, 75, Boulevard Haussmann, Paris, France.—Fig. 1 is a half longitudinal section of a furnace arranged in accordance with the invention; Fig. 2 is a corresponding transverse section taken on the axis of the hearth: Fig. 3 is a partial horizontal section on the line 3—3 of Fig. 1. The furnace comprises a hearth A, and twin regenerative chambers B B^1 arranged at the two ends of this hearth. The hearth communicates with each pair of regenerative chambers by flues C D, which are independent of the chambers but firmly connected with the hearth. The flues, which are arranged side by side, but separate from each other, debouch, when the furnace is in a position for melting, above the apertures *c* and *d* respectively corresponding to the chambers. At their lower end these flues are terminated by metal walls C^1 D^1, which in the position shown in Fig. 1, are immersed in a channel E containing a suitable liquid such, for instance, as water, the whole forming a water seal, which ensures tightness of the system, whilst preventing any escape to the outside of the air or gas circulating in C, *c*—D, *d*. The hearth is mounted on a platform *a* which simply bears on steel cylinders or rollers *g* suitably arranged, and serving as fixed axes about which the movable part of the furnace may tilt.

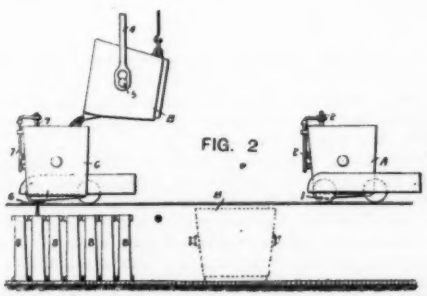


Improved Tilting Furnace.

When the movable part occupies the position shown in Figs. 1 and 2, that is to say a suitable position for the melting operation, it is evident that the furnace will act like a fixed Martin-Siemens furnace. It is important to remember that in such case the liquid seal formed at C^1 D^1—E prevents any escape of air or gas, and further, by reason of the separation of the flues C and D, no communication is possible between them, which would rapidly cause their deterioration.

16,601 (1911). *Manufacture of Ingot Iron and Steel.* G. Hatton, of Saltwells, Brierley Hill, Staffordshire.—Fig. 1 is a diagrammatic view illustrating the manner





Apparatus for the Manufacture of Ingot Iron and Steel.

in which the first part of the process is carried out, while Fig. 2 shows in a similar manner the carrying out of the remainder of the process. The molten steel is run from the Bessemer converter or open hearth furnace,

together with as much of the resulting slag as may be desirable, into a ladle A provided with the usual type of nozzle 1 and stopper 2 of ample dimensions, as shown in Fig. 1. Below the ladle A is placed a second ladle B which need not of necessity be provided with a nozzle and stopper, but which is preferably provided with trunnions 5 so placed as to enable it to be lifted and turned over by means of a crane or other mechanical appliance. When the whole of the charge of steel, together with any desirable portion of slag, has been poured or run into ladle A, the stopper 2 is lifted in in the usual way, and the molten steel 3 passes down through the nozzle 1 into ladle B, the whole of the slag being retained in ladle A by closing the stopper the moment the whole of the steel has passed through into ladle B. In ladle B the molten steel meets the metal, metallic alloy, or metalloid which it is desired to add to the steel, which metal, metallic alloy or metalloid is introduced into ladle B preferably in a heated condition, so that it is immediately taken up by the molten steel with which it combines. The ladle B is lifted by means of a crane or other mechanical appliance attached, as shown for instance at 4 supporting it by trunnions 5, and by this means its contents are quickly poured, in such a manner as to ensure a complete and intimate mixing of the already added metal, metallic alloy or metalloid, into a third ladle C, which is provided with the usual nozzle 6 and stopper 7, by means of which the steel it contains is teemed or fed into the ingot moulds 8 in the customary manner.

Queries.

Power for Fettling Shop Driving.

We are contemplating driving our fettling shop, which is situated 204 ft. from the engine-room, and would require for that purpose about 20 h.p. nominal. Several methods have been suggested for driving this machinery:—(*a*) Shafting with dust-proof roller bearings; (*b*) shafting with plain bearings; (*c*) by steel cable with large size driving pulleys and guide pulleys. Apart from the cost of erection we should like to know which would be the most economical and up-to-date method.—"Doubtful," Staffs.

Foundry Lighting.

We are building a new foundry covering about 1¾ acres, and are undecided as to the method of lighting. "Kieth" pressure gas has been mentioned, but our price of ordinary gas is rather high, being 2s. 2d. per 1,000. We have the "Kitson" system in our old foundry, and this is fairly economical, but requires constant attention and altogether is not quite so satisfactory as we should desire. The other alternative is electric light by 300 to 1,000 c.p. "Osram" lamps, and we might say we have ample surplus power for this purpose. We shall be glad to know which is found in practice to be the most economical and up-to-date.—"Doubtful," Staffs.

Core Sand for Motor Cylinders.

Can you give us particulars of a core mixture for motor cylinders which includes East Coast core sand and does not require venting, as we believe there is such a mixture in use.—"E. M. B."

Answer.—A mixture similar to that required is used by one East Coast firm, though the sand employed is from Birkdale, Southport. There is, however, a suitable East Coast sand. The mixture for ordinary work consists of one pint of "Spermolin" core oil (supplied by the Spermolin Core Company, George Street, Halifax) to six gallons of sand, the composition varying to one pint of oil to four gallons, according to the strength of core required. This is used on all cylinders from the very smallest up to 45 cwts. castings. For smaller work this firm do not find it necessary to use vents, though venting is practiced in the case of larger castings. We are indebted for this information to Mr. J. G. Robinson, Hon. Secretary of the Halifax Branch of the British Foundrymen's Association, who is preparing a Paper on "A Water-jacketted Cylinder for a Vertical Gas Engine," for the forthcoming annual Convention of the Association.—The EDITOR, "F.T.J."

"F.T.J." Bookshelf.

THE ELEMENTS OF ENGINEERING ESTIMATING.

By A. Suggate. London: Technical Publishing Company, Limited, 55-56, Chancery Lane, W.C.

This is a little book which we can confidently recommend to anyone who has to do with engineering work, especially on the estimating side. The author not only sets out to show the methods of estimating costs and the procedure to adopt, but gives practical examples, including in very many cases what may be described as average costs, so that the work not only appeals to those who have to make engineering estimates, but to those who are more or less unfamiliar with the cost of engineering work and who may be anxious to know how much a certain job will cost. The author first proceeds to discuss the meaning of estimates and then deals with market prices, diagrams, and methods of forecasting the probable market prices. He next considers methods of estimating the weight of material, which he does in two chapters. The cost of machining and the price of brickwork, timber, etc., are also dealt with fully. An important chapter is given to the determination of establishment charges and indirect or general expenses. Finally, the author gives some specimen methods of making up an estimate.

METALLURGICAL MANUAL OF IRON AND STEEL.

By Horace Allen. London: Technical Publishing Company, Limited, 55-56, Chancery Lane, W.C.

Mr. Horace Allen has had a very considerable experience in the iron trade, and was one of the pioneers in the application of blast-furnace gas for power apparatus, being associated with the late Mr. B. H. Thwaite in his early experiments. It is, however, a somewhat ambitious scheme to put before the public another text-book on the metallurgy of iron and steel when so many good ones exist. The author gives as the object in view, the placing before thousands of men and boys engaged in metallurgical processes some knowledge of the science of metallurgy. No doubt the work will serve its purpose, but in some respects it is by no means as up-to-date as might have been expected. In Chapter III., for instance, on "The Composition and Distribution of Workable Iron Ores," the author has frequently not brought his statistics beyond 1906, and in some cases not beyond 1894. Statistics that are many years out of date are not of much value unless they are accompanied by the latest figures for the purposes of comparison. These remarks do not, of course, apply to the metallurgical portion of the book, which does not so rapidly get old as the economic or statistical portions. Mr. Allen has also summarised a large number of records and results which have been published from time to time, and this should be found very handy. Here again, we are bound to state that he has hardly brought the information sufficiently up to date. The book, should, however, prove a useful one as the scheme of contents and the methods of handling the subject are unquestionably good.

Trade Talk.

MR. E. HOLT, trading as James Holt, Pilling Street Ironworks, Burnley, has been adjudicated bankrupt.

A. G. KIDSTON & COMPANY, LIMITED, of Glasgow, have removed their London offices to 148½, Fenchurch Street, E.C.

THE PEARLITE STEEL COMPANY, LIMITED, of Sheffield, have acquired the business of the Sesame Hacksaw Company, Sheffield.

A RECEIVING ORDER has been made in connection with the affairs of Mr. A. N. Scaman, ironfounder, of the Old Foundry, Great Grimsby.

MESSRS. F. G. BEDDOES and J. C. GREEN, carrying on business as engineers, smiths, press and die manufacturers, at Iron Bridge, Shropshire, under the style of Beddoes & Green, have dissolved partnership.

MESSRS. G. F. WEST & COMPANY, Caxton House, Westminster, London, S.W., have been appointed British agents for the Société Anonyme Aciéries et Fonderies d'Art de Haine-St.-Pierre et Métallurgique Lilloise.

ANDREW BARCLAY, SONS & COMPANY, LIMITED, Caledonia Works, Kilmarnock, have appointed Mr. Frank Percy, of Monument Cottage, Wigan, to act as their representative in Lancashire, Cheshire, and North Wales.

MESSRS. J. PINKSTON, B. O'REILLY, D. G. MACMILLAN, and E. N. READE, carrying on business as engineers and merchants, at Clun House, Surrey Street, London, W.C., under the style of O'Reilly & MacMillan, have dissolved partnership.

G. H. GLEDHILL & SONS, LIMITED, 153, Cheapside, London, E.C., and Trinity Works, Halifax, have bought all the patent-rights and the business and good-will of the Stockall-Brook Time Recorders, Limited, Empire Works, Huddersfield,

THE partnership heretofore subsisting between Messrs. W. K. Billings and H. J. Simpson, carrying on business as ironfounders, at the Abbey Foundry, Devonshire Road, Leicester, under the style of Billings and Simpson, has been dissolved.

AT a meeting of the members of the Brass Masters' Association, held recently, it was unanimously agreed that general discounts be further reduced 2½ per cent., and that all net prices be further advanced 5 per cent. from April 12 last.

THE copartnery of J. S. Gibson & Company, ironfounders, etc., trading as the Salton Iron Works, Falkirk, of which Mrs. H. Gibson and Mr. W. J. Gibson were the sole partners, has been dissolved by the retirement of the former.

MOULDING machines of the type made by Ph. Bonvillain and E. Ronceray, of Paris, have recently been installed at the works of William Cross & Son, Limited, West Bromwich, and Samuel Osborn & Company, Limited, Sheffield.

THE partnership heretofore subsisting between Messrs. W. Morton and E. L. Scott, lately trading as engineers and machinists, at Wellington Works, 109, Rockingham Lane, Sheffield, under the style of E. L. Scott & Company, has been dissolved.

MR. W. CARR, 27, Regent Street, Barnsley, has been appointed trustee in connection with the affairs of Mr. W. Charlesworth, engineer, High Street, Dodworth, near Barnsley, carrying on business at the Albion Forge and Engineering Works, Dodworth.

THE partnership heretofore subsisting between Messrs. P. E. L. Crawshaw, J. Mitchell, and E. Mitchell, carrying on business as engineers, millwrights, and smiths, at Statham Street, Pendleton, under the style of Crawshaw & Company, has been dissolved.

MESSRS. J. & J. COCHRANE, engineers and boilermakers, Bo'ness (of which firm John P. Cochrane and James B. Cochrane were the partners), have granted a trust deed on behalf of their creditors in favour of Mr. J. Shiels Alexander, 44, Queen Street, Edinburgh.

A NEWLY-FORMED private company, known as Anderson, Brown & Company, Limited, has acquired offices and extensive warehouse accommodation at 348, Leith Walk, Leith, where business will be conducted as iron, metal, and steel merchants and engineers' and colliery furnishers.

MESSRS. W. TETSTALL, E. JENKINS, and C. V. REA, Derby Road, Worcester, carrying on business as the Industrial Foundry, have dissolved partnership. The business and assets have been sold to the Industrial Foundry and Engineering Company, Limited, who will continue the business.

A FIRE occurred, recently, in the pattern shop of Messrs. R. & A. Mains' Gothic Ironworks, Camelon, Falkirk. It was found to be impossible to save the shop, so the efforts of the firemen were directed to saving the adjoining buildings. The damage is estimated at £1,000.

MESSRS. J. W. COLDMAN and F. G. PIGOTT, carrying on business as lift and crane and general engineers, at 28 to 30, Southwark Bridge Road, London, S.E., under the style of R. Easton & Son, have dissolved partnership. Mr. F. G. Pigott will continue the business under the style of R. Easton & Son.

THE partnership heretofore subsisting between Messrs. S. Husbands and A. Krause, as machine builders and general machinists, at Long Eaton, Derby, under the style of S. Husbands & Company, has been dissolved. Mr. S. Husbands will continue the business under the style of S. Husbands & Company.

A GENERAL meeting of the members of the Lancashire Metal Refining Company, Limited, will be held at 5, Bold Street, Warrington, on Saturday, May 18, for the purpose of having the liquidator's accounts, showing the manner in which the winding-up has been conducted and the property of the company disposed of, laid before such meeting.

NOTICE is given that, at the expiration of three months, the names of the undermentioned companies will, unless cause is shown to the contrary, be struck off the Register of the Joint Stock Companies, and the companies will be dissolved :—Beaumont Machinist Company, Limited, Bennetts Brass Company, Limited, British Engineering Syndicate, Limited, British Stamped Metal Ceiling Company, Limited, Metals Corporation, Limited, and the Vulcan Engineering Company (Middleton), Limited.

JAMES KEITH & BLACKMAN COMPANY, LIMITED, have decided upon another extension of their engineering works at Arbroath. Some time ago they acquired an extensive stretch of ground, and recently additions were made to the works, but the extensions which are about to be made will be on a more elaborate scale. Plans have been lodged with the burgh authorities with a view to their receiving the sanction of the Dean of Guild Court, and these show that it is proposed to construct an extensive range of workshops, giving employment to some 200 or 300 extra hands.

MR. VICTOR STOBIE, engineer and metallurgist, 6, Foster's Buildings, High Street, Sheffield, has sold the business of the Sheffield Annealing Works Company as a going concern, and the same will be continued as heretofore under the same name. The transfer is strictly limited to the business of the Sheffield Annealing Works Company, who will continue as annealers and heat-treaters to the trade. It has been occasioned by the growth of the electric steel business conducted under the title of the Stobie Steel Company. Mr. Stobie has taken temporary offices at 6, Foster's Buildings, until new premises have been built for the Stobie Steel Company.

NEGOTIATIONS are in progress for the purchase by Workman, Clark & Company, Limited, of Belfast, of the Belfast engineering works and foundry of Fairbairn Lawson Combe Barbour, Limited, of Leeds and Belfast. The works, which are situated in the north end of the city, find employment for about 1,600 hands, but at the present time are idle for want of raw material. The main production of the Belfast works is textile machinery, but boilers and engines are also built, and it is understood to be the intention of the new owners to develop the foundry, so as to produce in the city the large number of castings at present imported from England and Scotland, principally Glasgow.

MECHAN & SONS, LIMITED, Scotstoun Ironworks, Glasgow, on April 12 entertained at dinner their staff, fore-

man, and all workmen who were in the employment of the firm while the works were at Cranstonhill, but who migrated to Scotstoun, and who had remained in that employment ever since. The occasion was the jubilee of the firm, which was founded in 1862. Mr. Arthur Mechan presided, and about 250 gentlemen were present, the company including Mr. Aulay Bain, Mr. James Mechan, Mr. Wm. Porteous, Mr. Henry Mechan, Mr. Dudgeon, sen., Mr. John Steven, Mr. Robert Morgan, Mr. Samuel Mechan, Mr. F. J. Trewent, Mr. G. P. West, and Mr. T. C. Young.

THE ATLAS STEEL FOUNDRY AND ENGINEERING COMPANY, LIMITED, is about to restart the works of the defunct Armadale Iron Company for the manufacture of steel castings, and to carry on the business of general engineers. It is intended to enlarge the old works, and to put in the latest machinery. The present building will be extended to about 110 ft., and there is to be a large dressing shop, blacksmiths', joiners', and patternmakers' shops, besides a large extension of the foundry. The power used will be electric, and will be generated by the Company themselves. Three electric overhead cranes will be installed. The works will be under the charge of Mr. D. M. Cunningham, the managing director of the company, who has had considerable experience of this class of work.

THE prospectus has been issued this month of the Scottish Tube Company, Limited, which has a share capital of £750,000, divided into 300,000 5 per cent. cumulative preference shares of £1 each, which are preferential both as to capital and dividend, and 450,000 ordinary shares of £1 each. The capital issued is £506,955, consisting of 300,000 cumulative preference shares and 206,955 ordinary shares which, except the shares already allotted for cash to the subscribers of the memorandum of association, are to be allotted partly as fully paid to the vendors in part-payment of the purchase price, and partly to Stewarts & Lloyds, Limited, for cash. Of the balance of ordinary shares, 200,000 will be reserved against conversion of debenture stock, and 43,045 will be available for future issue. The company have offered to the public £200,000 5 per cent. convertible mortgage debenture stock at par. The trustees for the debenture stockholders are:—Mr. T. Cuthbert Stewart, of Stewarts & Lloyds, Limited, Glasgow; and Mr. W. H. Kidston, of Messrs. A. G. Kidston & Company, Glasgow. The directors of the company are:—Sir Thomas Mason, Craigie Hall, Bellahouston, Glasgow, chairman; Mr. Thomas Davie, chairman of the Wilsons and Union Tube Company, Limited; Mr. Patrick William Hendry, chairman of Hendry Brothers, Limited; Mr. Andrew Eadie, Clydesdale Tube Works, Rutherglen; Mr. David Marshall, Glasgow Tube Works, Swanston Street, Glasgow; Mr. James Alexander Richmond, City Tube Works, 35, Rose Street, Glasgow, director of David Richmond & Company, Limited; and Mr. John Symington, Union Tube Works, Coatbridge, director of the Wilsons and Union Tube Company, Limited. The last four gentlemen are managing directors. The secretary of the company is Mr. Andrew Fulton, and the registered offices (pro tem.) are at 5, Wellington Street, Glasgow. The company has been formed for the purpose of acquiring, amalgamating, and carrying on as one concern the businesses of manufacturers of iron and steel boiler tubes, gas, water, and steam tubes, and other classes of tubes, fittings, and accessories carried on by the undermentioned concerns, who are the vendors to the company, viz.:—The Caledonian Tube Company, Coatbridge; Coats Tube Company, Coatbridge; James Eadie & Sons, Clydesdale Tube Works, Rutherglen; Hendry Bros., Ltd., Saracen Tube Works, Garnkirk; John Marshall & Sons, Glasgow Tube Works, Glasgow; David Richmond & Company, Limited, City Tube Works, Glasgow, and North British Tube Works, Govan; Tradeston Tube Company, Glasgow; Wilsons & Union Tube Company, Limited, Union Tube Works, Coatbridge; and Govan Tube Works, Govan. Stewarts & Lloyds, Limited, will have a holding of preference and ordinary shares in the company to the amount of £25,000, and, in respect thereof, are to have the option to nominate a director at any time before the ordinary general meeting in 1913.

Deaths.

MR. T. G. WATSON, at one time secretary of Mather & Platt, Limited, died recently aged seventy-two years.

MR. J. BASS, at one time a partner in the Parker Foundry Company, Derby, died recently at the age of 64 years.

THE death is announced of Mr. R. G. Ross, J.P., of the firm of Messrs. R. G. Ross & Son, Greenhead Engine Works, Glasgow.

THE death took place recently of Mr. H. Crabtree, works manager to the Birmingham Battery and Metal Company, Limited.

MR. J. D. CULBERTSON, vice-president and treasurer of the National Tube Company, Pittsburg, died recently at the age of 67 years.

THE death is announced of Mr. F. J. Allsop, of Clayton & Shuttleworth, Limited, Lincoln. The deceased was 89 years of age.

THE death took place in Glasgow recently of Mr. Gilbert Little, who was recognised as one of the pioneers in conveying machinery manufacture.

THE death has taken place at Weston-super-Mare of Mr. William Allman, a gentleman well known in Birmingham business circles, as a director of Cope & Timmins, Limited, brassfounders, Birmingham.

MR. ROBERT HUDSON, of the Gildersome Foundry, Gildersome, near Leeds, has died suddenly, at the age of 72 years. He commenced business as an engineer at Gildersome many years ago, and the business is now continued by his sons.

THE death is announced at Christiania, Norway, on April 6, of Mr. John C. Bull, managing director of Bull's Metal and Melloid Company, Limited, Yoker. Mr. Bull, who was a native of Norway, came to this country in 1884, and four years later invented and patented the alloy which afterwards became widely known as Bull's metal.

MR. BENJAMIN WHITELEY, of Ulverston, whose death is reported at the age of 69, was a native of Leeds, having been born at Bramley. He was brought up as an engineer, being apprenticed to Messrs. Fairbairn & Company, and he spent the best part of his life in engineering establishments in the Lancashire district, where he invented several machines.

AMONGST the passengers on the ill-fated "Titanic" were Mr. W. E. Hipkins, managing director of W. & T. Avery, Limited, of Birmingham; Mr. Howard B. Case, managing director of the Vacuum Oil Company, of London; and Mr. T. Andrews, jun., a managing director of Messrs. Harland & Wolff, the builders of the vessel. We regret to state that none of these gentlemen were among the survivors.

THE death is announced from La Louvière, Belgium, of M. Gustave Boël, a well-known ironmaster of that town. Since 1880 M. Boël has been the proprietor of the Usines de La Louvière, which were founded in 1850 by M. Ernest Boucquéau, and which have since assumed considerable importance. M. Boël was the first steel maker in the Province of Hainaut to produce steel by the Bessemer process.

THE death took place recently at his residence, Sunninghill, Harrogate, of Mr. William Wilson, formerly of Newcastle, aged 90 years. Mr. Wilson entered into partnership with Mr. Ralph Nicholson, of Ryton, and took over the Blaydon Iron Works, which had been owned by Messrs. Hawdon. They conducted the business with great success for over twenty years, and acquired a wide reputation for their manufactures. The deceased gentleman retired from business in 1882, and had for some time been resident at Harrogate.

PROFESSOR EDWARD DIVERS died recently at his residence in London. The deceased gentleman was born in 1837, was educated at the City of London School, the Royal College of Chemistry, and Queen College, Galway, and became a Fellow of the Chemical Society in 1860, and one of its vice-presidents in 1900. In 1873 he was selected by the Japanese Government as a

AS SUPPLIED TO THE ADMIRALTY, WAR OFFICE,
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THE Cupola.
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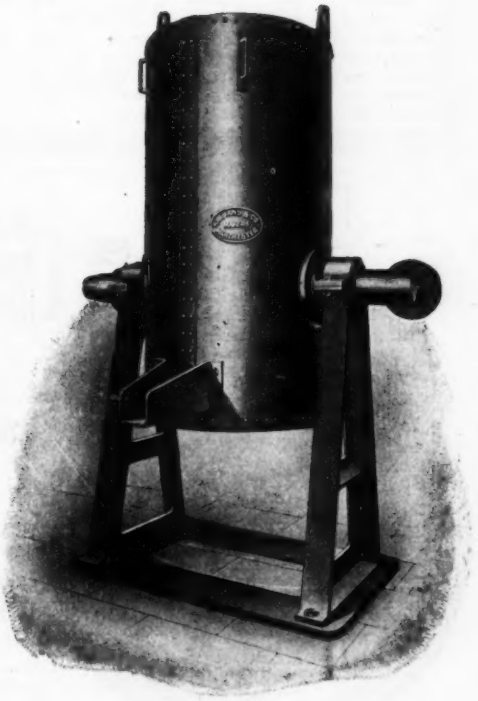
Foundries Completely Furnished.

EVANS'S NEW CUPOLETTE
For Emergency Work.



James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.

Telegrams: "LADLES, MANCHESTER."

member of the band of English scientific and technical men to form the teaching staff of the Imperial College of Engineering at Tokio. He subsequently became Principal of the College.

THE death took place recently of M. Henri-Aimé Brustlein, well known in connection with the Unieux Steel Works, for which he was consulting director at the time of his death. M. Brustlein devoted special attention to the production of chrome steel, and the works with which he was associated became well known for the use of chrome steel in the manufacture of projectiles. Apart from various other awards the deceased was appointed officer of the Légion d'Honneur in 1901. M. Ferdinand Valton, a second French engineer, who recently passed away, became connected with the Terre Noire works in 1863, where he erected the first Bessemer plant, blast furnace and open-hearth plant. In 1874 he took up the management of the Société des Fers et Aciers par Alliage de Manganèse, and was called upon to establish the open-hearth steel works of Alexandrowski, on the Neva, above St. Petersburg. M. Valton, who received the cross of the Légion d'Honneur in 1876, in connection with the French Exhibition in that year, also gained a reputation for having been the first to give a rational explanation of the part played by manganese in the final addition in the Bessemer process. M. Charles Marrel, who also recently died, was associated with his brother, E'tienne, under the title of Marrel Frères, who established the Rive-de-Gier works and the Usine des E'taings, for the special manufacture of armourplate and chains and anchors for the navy. A fourth Frenchman whose death is announced is that of M. Louis Troost, member of the Acadimie des Sciences, who assumed the chair of general chemistry at the Faculti des Sciences in 1874. The deceased, either alone or in connection with M. Haute-Genille, made numerous researches in regard to the composition of iron and manganese and of their reactions in blast-furnaces and Bessemer converters.

Personal.

MR. H. F. WRIGHT has resigned the position of general manager of C. & W. Walker, Limited.

MR. JOHN FRITZ has been elected an honorary member of the Verein Deutscher Eisenhuettenleutte.

THE late Sir Theodore Fry, of Beechanger Court, Caterham, and Woodburn, Darlington, left estate valued at £40,899.

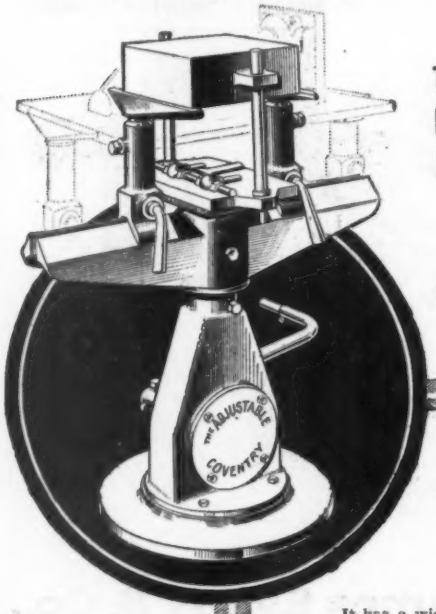
THE late Mr. W. D. Vaughan, ironfounder, of Edgbaston, Birmingham, left estate of the gross value of £25,575, of which £9,881 is net personalty.

MR. SYDNEY JESSOP ROBINSON, managing director of W. M. Jessop & Sons, Limited, who has recently been in indifferent health, has, we regret to hear, been obliged to undergo an operation.

THE will has been proved at £71,853 of the late Sir John G. N. Alleyne, Bart., who was associated with the Butterley Company, Limited, was an original member of the Iron and Steel Institute, and sole survivor of its first Council.

THE late Mr. D. J. Dunlop, of Messrs. David J. Dunlop & Company, shipbuilders and engineers, of Port Glasgow, and chairman of Alley & MacLellan, Limited, Polmadie, Glasgow, left personal estate of the total value of £10,453, of which £10,260 is in the United Kingdom and £8,961 in Scotland.

MR. CHARLES DAY, the newly-elected president of the Manchester Association of Engineers, was educated at Stockport Grammar School and the Manchester School of Technology. From his evening classes there he obtained a. Whitworth Scholarship. For the last ten years he has been managing director of the Mirrlees Watson Company, Limited, of Glasgow, and he is also managing director of Mirrlees, Bickerton & Day, Limited, of Hazel Grove. He takes a great interest in the Manchester School of Technology, and is a member of the committee.



THIS IS THE SIMPLEST AND MOST EFFICIENT HAND RAMMED MOULDING MACHINE, FOR WHICH PATENTS HAVE BEEN APPLIED. NOTE THE RANGE OF WIDTHS - - - GREATER THAN ALL OTHERS.

Does the work of four men at the cost of one.

This Adjustable Moulding Machine is Instantly Adjustable to take any width box from 6in. to 24in., length being unlimited.

It has a wider range than any other Hand Rammed Machine, draws patterns 8 inches deep perfectly, and can be fitted with head for Power Ramming, therefore it is the most efficient and economical Hand Rammed Moulding Machine Manufactured.

LET US SEND YOU PARTICULARS.

THE ADJUSTABLE MOULDING MACHINE CO.,

WEST ORCHARD WORKS, COVENTRY. P.P.Co.

PURE METALS

and ALLOYS. FREE from CARBON.

TITANIUM THERMIT

for

SOUND, STRONG, CLOSE-GRAINED CASTINGS.

Also FERRO VANADIUM and FERRO TITANIUM.

Full Particulars and PRICES from—

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ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

METALS.	End April, 1912.	End April, 1911.
Iron—Scotch pig warrants ton	*60/1½	*52/7½
—Middlesbro' warrants ... ton	54/2½	48/9
—W.C. M/nos Bessemer ... ton	71/0	65/6
—Stock, Scotch ... ...tons	1,000	1,000
Copper—Chili bars, GMB ton	£70 5 0	£54 16 3
—Stock, Europe and afloat tons	—	—
Tin—English ingots ... ton	£203 0 0	£192 0 0
—Straits ... ... ton	£203 10 0	£191 5 0
—Stock, London, Holland, U.S.A., and afloat ...tons	—	—
Lead—English pig ... ton	£16 17 6	£13 3 9
Spelter—Ord. Silesian ... ton	£25 17 6	£24 1 3
Quicksilver (75lb)... bottle	£8 12 6	£9 0 0
Antimony—Regulus ... ton	£27 0 0 £27 10 0	£35 0 0
Aluminium—Ingot ... ton	£67 0 0	

* Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (plain)	6 10 0	to	6 15 0
Pipes, 1½ to 2½ in.	5 7 6	to	5 15 0
,, 3 to 4 in.	5 2 6	to	5 5 0
,, 5 to 8 in.	5 0 0	to	5 2 6
,, 10 to 16 in.	5 0 0	to	5 2 6
,, 18 to 24 in.	5 0 0	to	5 2 6
Chairs	3 15 0	to	3 17 6
Floor plates (open sand)	3 5 0	to	3 7 6

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows: Heavy wrought (mixed), £2 10s. 0d.; light wrought, £1 5s. 0d.; heavy cast, £2 10s. 0d.; all per ton, f.o.b., London. Copper (clean), £64 10s. 0d.; brass (clean), £45 0s. 0d.; lead (usual draft), £15 10s. 0d.; zinc, £20 10s. 0d.; all per ton delivered merchant's yard.

New Companies.

BRITANNIA LATHE AND OIL ENGINE COMPANY, LIMITED.—Capital £2,000 in £1 shares.

EFFICIENCY, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of engineers, etc.

MARK WEBBER, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of ironfounders, etc.

EDWIN MILLS & SON, LIMITED.—Capital £10,000 in £1 shares, to carry on the business of engineers, etc.

KERMODES, LIMITED.—Capital £10,000 in £1 shares, to carry on the business of oil and gas engineers, etc.

STEEL WORKERS, LIMITED.—Capital £3,000 in £1 shares. Registered office: Titan Works, Charles Henry Street, Birmingham.

CLARKE & BROWN, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of ironmasters, etc. Registered office: Penshaw Station.

EMPIRE ENGINEERING COMPANY (MANCHESTER), LIMITED.—Capital £20,000 in £1 shares. Registered office: Empire Works, Clarendon Road, Salford.

LEADERS, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of machinery manufacturers. Registered office: 37, Surrey Street, Sheffield.

BURMEISTER & WAIN (DIESEL SYSTEM) OIL ENGINE COMPANY, LIMITED.—Capital £550,000 in 530,000 preference shares of £1 and 400,000 deferred of 1s.

BRITISH STILL TUBE COMPANY, LIMITED.—Capital £40,950 in 38,000 participation preference shares of £1 and 59,000 ordinary of 1s. Registered office: Skerne Works, Darlington.

BRASS FLASK AND CAPSULE COMPANY, LIMITED.—Capital £5,000 in £1 shares, to take over the business of brass founders and manufacturers carried on by the Brass Flask and Capsule Company, at Shadwell Street, Birmingham, and to adopt an agreement with G. S. Thompson and T. H. Hodgkinson.

FOUNDRY CUPOLAS!

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Finest Workmanship and Materials.

SEND for QUOTATIONS

Our PRICES will interest YOU

The DERBY BOILER Co., Ltd.,

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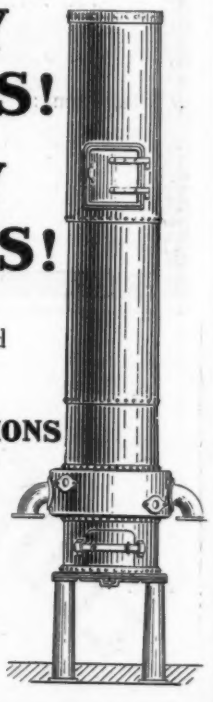

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

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Telegrams: "LOWOOD, DEEPCAR."

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.

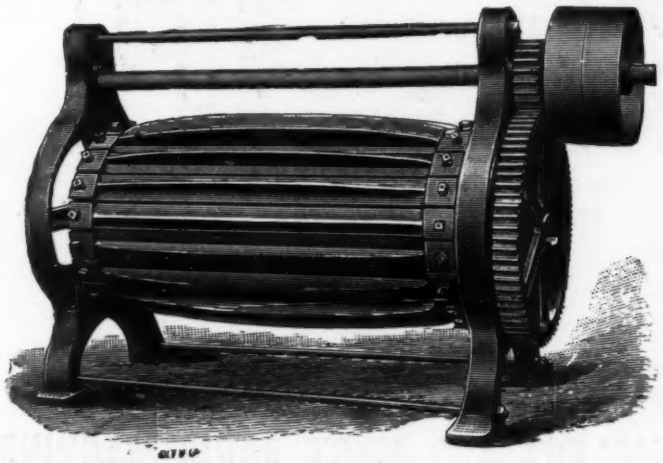
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

The London Emery Works, Co., PARK WORKS,

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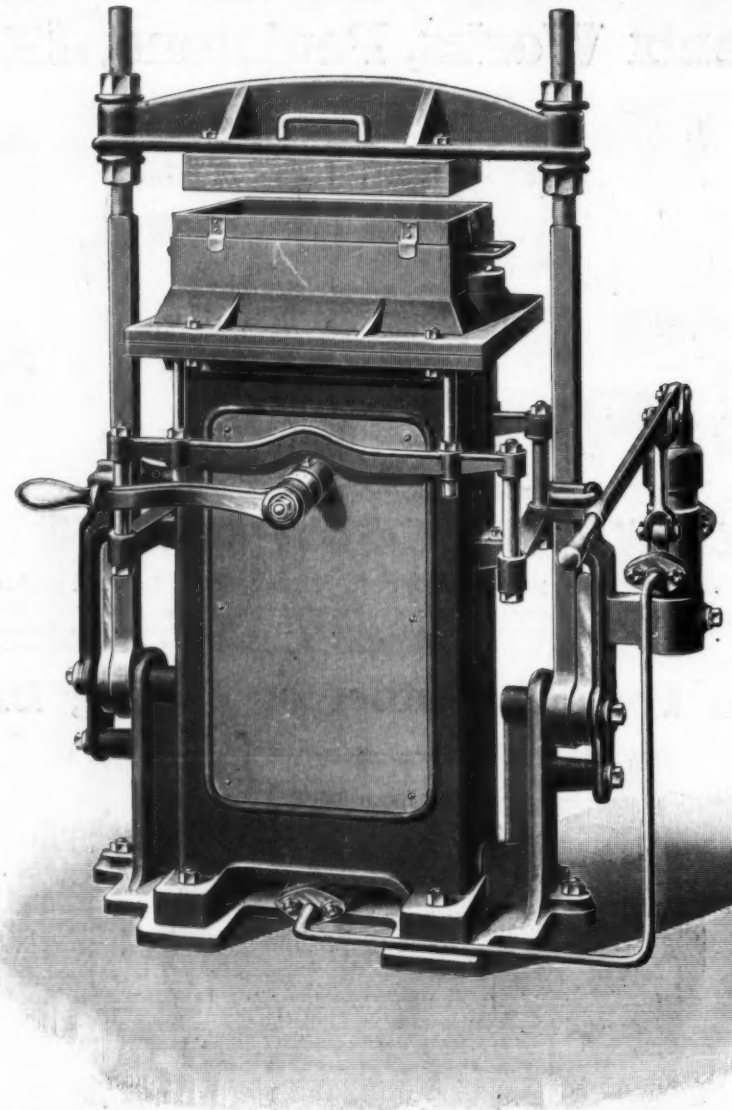

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THE SIMPLEST AND MOST RAPID MACHINE MADE.

The working parts are so conveniently arranged and operate with such facility that a mould can be rammed and put down on the floor in ¾ minute. This means that the moulder can produce three times as many boxes as by hand and, further, every mould is perfect and all castings alike.

INVALUABLE in ALUMINIUM, BRASS and MALLEABLE IRON FOUNDRIES. Send us sample castings or drawings of your work and we will tell you what can be done.

Sort them out Now, and Write To-day.

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Olsen, Wm.
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Cumming, Wm. & Co., Ltd.
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Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W. & Co., Ltd.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd

Core Making Machines.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W. & Co., Ltd.
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London Emery Works Co
Marshall, H. P. & Co.
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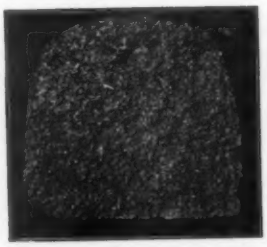
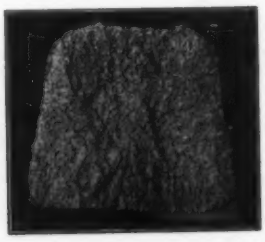

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ALL TYPES AND SIZES IN STOCK OR PROGRESS.

LICENSEES and MAKERS of

Osborn's Patent Spark Arrester

FOR FOUNDRY CUPOLAS.

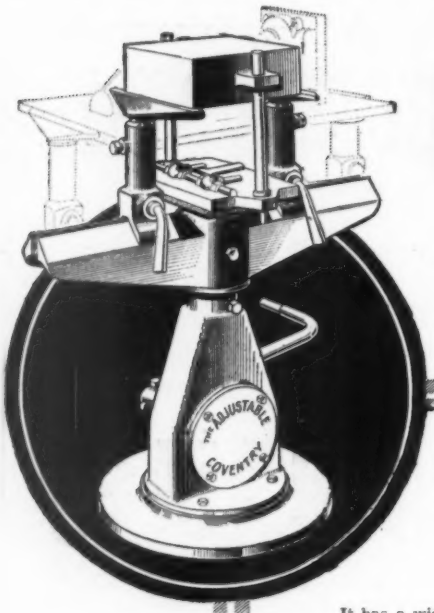
Efficient. Simple in Design.

Require no Attention.

Prevent Fire or Damage to Surrounding Buildings.

SAVE THE COST OF FREQUENT CLEANING OF THE ROOFS AND GUTTERS.

THOROUGHLY RELIABLE.



THIS IS THE SIMPLEST AND MOST EFFICIENT HAND RAMMED MOULDING MACHINE, FOR WHICH PATENTS HAVE BEEN APPLIED. NOTE THE RANGE OF WIDTHS - - - GREATER THAN ALL OTHERS.

Does the work of four men at the cost of one.

This Adjustable Moulding Machine is Instantly Adjustable to take any width box from 6in. to 24in., length being unlimited.

It has a wider range than any other Hand Rammed Machine, draws patterns 8 inches deep perfectly, and can be fitted with head for Power Ramming, therefore it is the most efficient and economical Hand Rammed Moulding Machine Manufactured.

LET US SEND YOU PARTICULARS.

THE ADJUSTABLE MOULDING MACHINE CO.,
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FIRE BRICKS & CLAY

CUPOLA BRICKS.

BEST QUALITY.

LESSEES OF DELPH AND TINTERN ABBEY BLACK AND WHITE CLAY.

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(STOURBRIDGE) Ltd.,
STOURBRIDGE.

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The British Foundry Cement.

FOR FILLING UP BLOW HOLES IN CASTINGS . . . . . IT DRIES IN ONE HOUR, AND IT CAN BE FILED UP IN FROM SIX TO TWELVE HOURS . . . .

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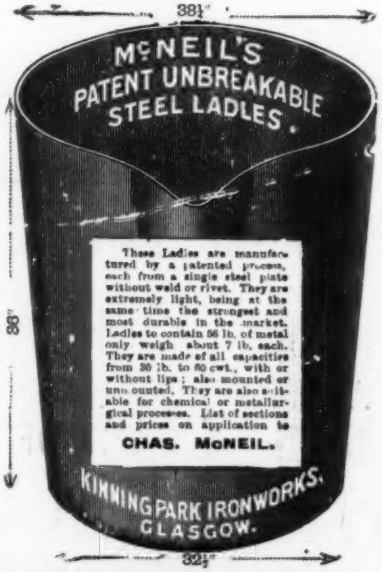
38½"
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES.
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical or metallurgical processes. List of sections and prices on application to
CHAS. McNEIL.
KINNING PARK IRONWORKS,
GLASGOW.
36"
32½"

Can also be made in Aluminium.

Scrap Heap Reduced to a Minimum.

METALLINE CEMENT COMPOUNDS.

REGISTERED

TRADE MARK.

INDISPENSABLE IN THE FOUNDRIES AND ENGINEERING WORKSHOPS NOW RECOGNISED TO BE THE **MOST RELIABLE IRON COMPOUNDS** THAT CAN BE PROCURED.

VALUABLE for treating defective Castings, making permanent repairs to Engines, Boilers, Tanks, etc., etc.

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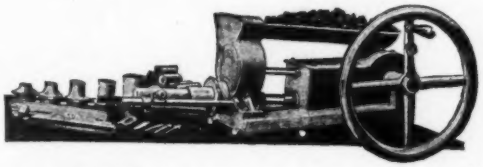

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Tilting Furnaces-Oil & Coke Fired, Moulding Machines, Core Machines, Sand Mixers, Ash Pulverisers & Washers, Mould Driers.

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IF YOU WANT TO HAVE THE LEAST TROUBLE AND THE BEST RESULTS IN YOUR MOULDING AND ENAMELLING DEPARTMENTS USE

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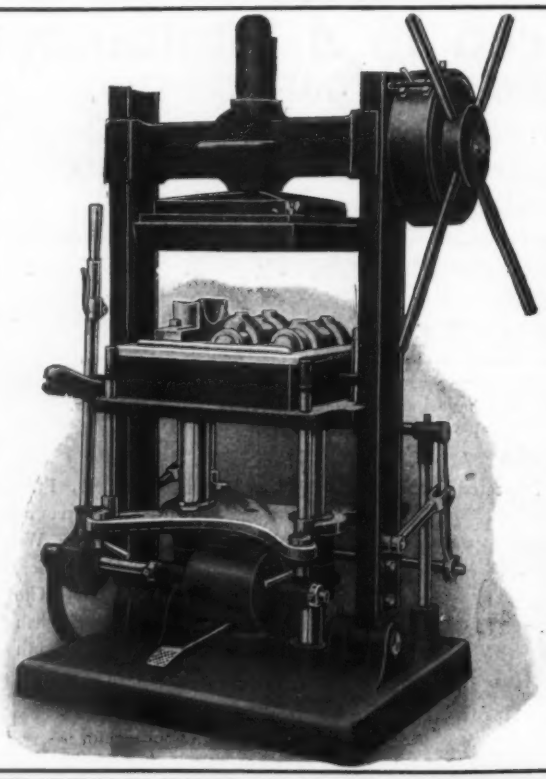

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SO GREAT IS OUR CONFIDENCE IN THE "COVENTRY" PATENT MOULDING MACHINE'S ABILITY TO SELL ITSELF—THAT WE HAVE DECIDED TO PLACE SOME OF OUR NEXT BATCH IN A FEW APPROVED FOUNDRIES FOR 30 DAYS' FREE TRIAL.

SHOULD YOU LIKE ONE? IF SO MAKE EARLY APPLICATION, AND SAY THE CLASS OF CASTINGS YOU WISH TO PRODUCE.

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BRITANNIA FOUNDRY CO.,

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FERRO-VANADIUM. * * * FERRO-TITANIUM.

SILICO-MANGANESE {23/30 % Silicon, 65/70 % Manganese & 1 %, 2 %, 3 %, Carbon Maximum.

FERRO-SILICON Containing 25 %, 50 %, 75 % Silicon.

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ALUMINIUM 98/99 % Purity. *In Notched Bars and Half Round Sticks and Granular.*

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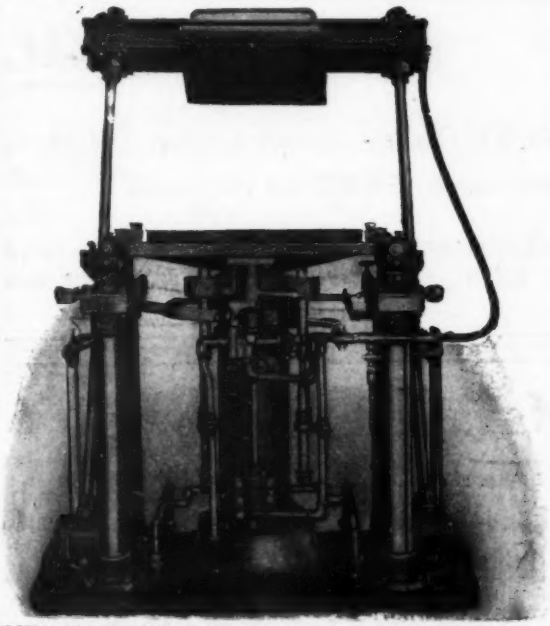

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The Machine that is suitable for deep and shallow work.

The Machine that will make a complete mould in a few seconds without any hand work, forms the sand hardest about the pattern.

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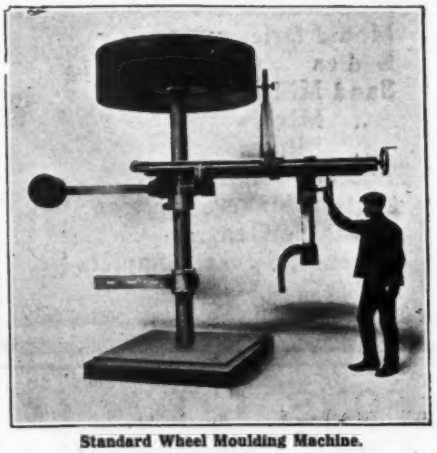

Standard Wheel Moulding Machine.

ALL IRON AND STEEL FOUNDRIES

SHOULD BE EQUIPPED WITH

STEWART WHEEL MOULDING MACHINES.

Complete Satisfaction Guaranteed

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No Loose Parts Liable to be Lost.

ACCURATE. PORTABLE. CHEAP.

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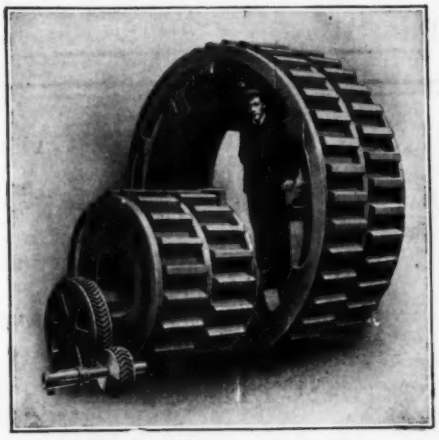

Wheels Moulded by this Machine.

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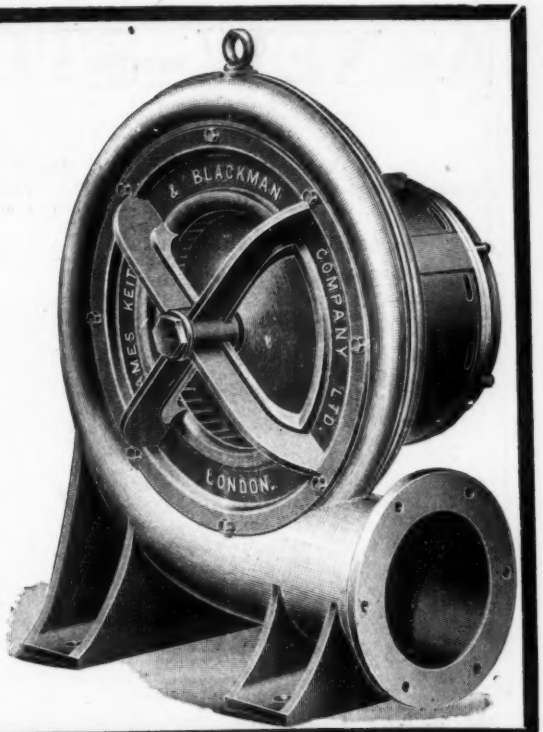

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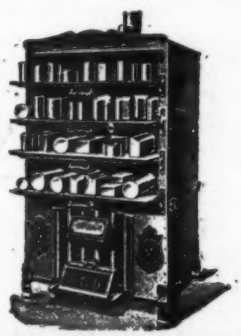

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PORTABLE CORE OVENS

For Gas or Fuel.

TESTIMONIAL.

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Gentlemen,

We are very pleased with the Core Oven we recently purchased from you. We find it dries the cores quickly without burning them. It is very handy and economical to use and is altogether superior to other ovens of this type we have in use.

Will you please quote us your best price for four more like it.

Yours faithfully,
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(Signed) W. B. LAKE, Director

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The Handiest and Cheapest Barrow in the market. Specially designed for coal, dross, ashes, etc. Its capacity is **25 per cent. greater** than the ordinary style, yet it can be wheeled with **half the labour**, and can be emptied **much more quickly**. It is a **perfectly balanced** barrow, and a full load can be **easily wheeled by a boy.**

NOTE.—This Barrow can be taken right up to mouth of furnace and the ashes drawn into the barrow direct from the furnace.

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BRABY for high grade **STEEL**
SHEETS & PLATES up to 15 FEET LONG.
RANGE of GAUGES 8 to 30 W.G.
RANGE of WIDTHS 12 to 60 in.

BRABY for improved wrought **STEEL**
BARROWS. BOGIES. TRUCKS.
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Finest Workmanship and Materials.

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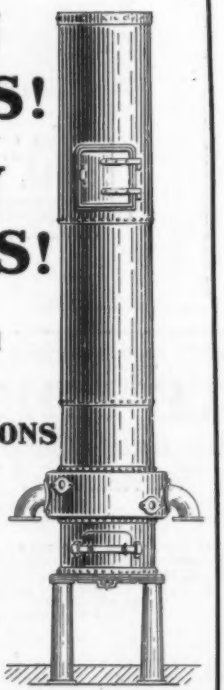

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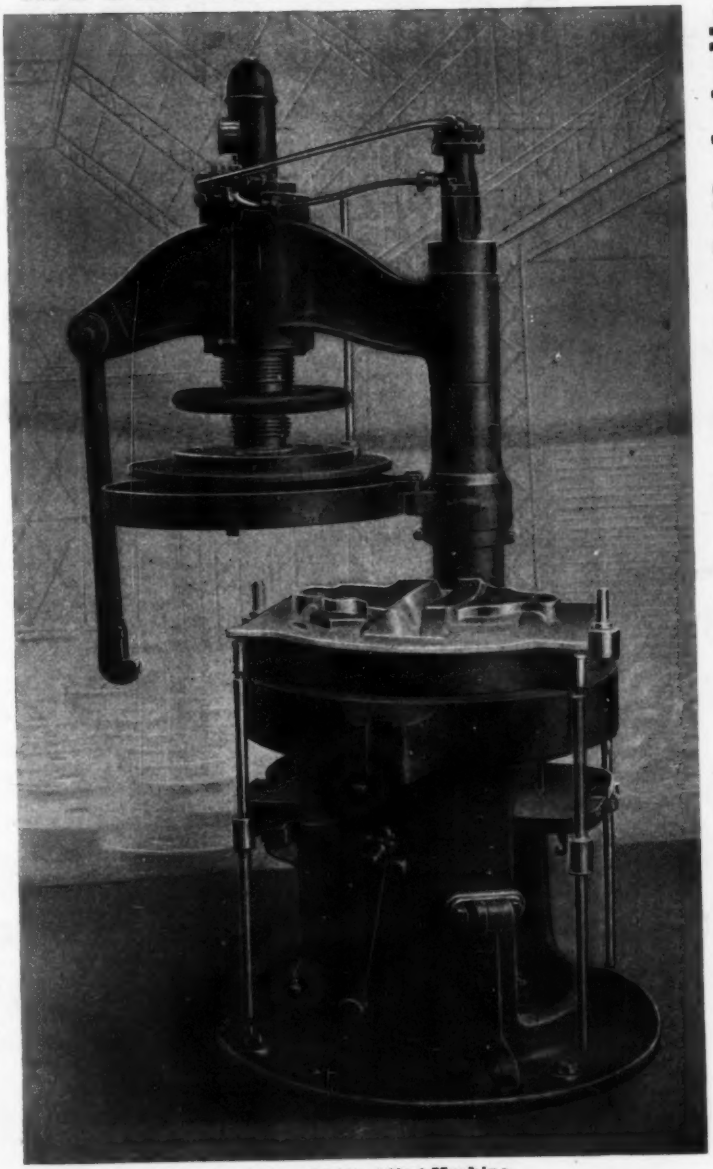
One of our representatives will be pleased to call by appointment.



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This is a reversible Pattern Plate, with Stripping Plate of a **Railway Carriage Brake Block.**
Output: 15 to 20 Moulds (30 to 40 castings) an hour. Two Men. Round cores in green sand made in the mould itself.

On receipt of blue prints (containing full details of the casting), or better still the Casting itself, we will give you the guaranteed output of a machine suitable for your purpose.

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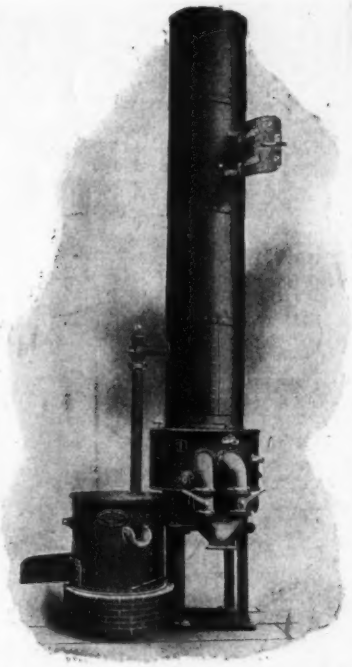

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